# The Collective Investigations into the Bear Lake Basin

History

Geology

Biology

People

# The Collective Investigations into the Bear Lake Basin

History, Geology, Biology, People

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## Table of Contents



## SECTION HEADINGS

## LIST OF FIGURES

## LIST OF GRAPHS



## LIST OF TABLES

## LIST OF PHOTOS AND CREDITS

# EXECUTIVE SUMMARY


Bear Lake is a large, deep lake located on the border of Utah and Idaho in Rich County Utah and Bear Lake County Idaho. It was formed through seismic activity along a fault on the eastern side of the lake. Tectonic shifts of the plates along this fault resulted in a lake basin that is over 200 ft deep along the eastern shore with a gradual slope to the western shore. The lake water has high concentrations of calcium carbonate because of high levels of evaporation typical of this semi-arid climate. These high concentrations of calcium carbonate give the lake it's bright blue color.

The three largest towns along the lake shore are Garden City, Utah, and Fish Haven and St. Charles, Idaho. Most of the region is rural in nature with economic activity coming mostly from agriculture and recreation. The population of the region has remained fairly stable during the past century. Historically the region was used by Shoshonie, Bannock, Ute, Sioux, and Blackfoot Indian tribes, primarily during spring and summer periods.

Water in the Bear Lake basin has been used for irrigation and electrical generation since the late 1800's. The Utah Power and Light Company secured water rights to Bear Lake water in 1912 and began construction of canals linking Bear River and Bear Lake from 1914-1917. These canals and the Lifton pumping station allowed the Utah Power and Light Company to use the top 20 ft of Bear Lake water for electrical generation and irrigation. The Bear River Compact, a collaborative effort by the states of Utah, Idaho, and Wyoming, provides for the distribution of water on the Bear River.

Recreational use of Bear Lake has increased tremendously during the past ten years. Sales of fishing licenses, visits to state parks along the shore, and boating activities have all increased by nearly 50% during the past decade. Snowmobiling has become a significant winter recreational activity during recent years. Managing the growth of recreational use and the accompanying increase in seasonal homes will be a major focus of county planning activities in the near future.

Bear Lake continues to support an active sport fishery. Cutthroat trout and lake trout are the fish most desired by anglers, but whitefish are the most abundant fish caught. In recent years the exotic yellow perch have been captured by anglers. The high quality of the fishing experience at Bear Lake is demonstrated by the designation of the lake as one of Utah's "Blue Ribbon Fisheries".

During much of the earth's existence, the Bear Lake Basin was filled by a shallow sea. Abrupt uplift of the surrounding area approximately 70 million years ago resulted in a changing climate and elimination of the saline waters. Bear Lake was formed about 150,000 years ago. The lake was shallow during much of its existence. Shifts in the faults along the eastern and western shores of the lake around 8,000 year ago resulted in its present shape and structure. These faults are still active today. The geology of the region is dominated by limestone deposits which provide the calcium carbonate that enters the lake through weathering processes. Deposits of phosphorus are also present and support limited mining of this mineral in the watershed.

The climate of the Bear Lake region is cold and dry as is typical of areas at 6000 feet elevation in the intermountain west. Ice forms on the lake in most winters with complete loss of open water one out of every three years. Precipitation falls mainly as snow, with total precipitation averageing 13 inches per year. Evaporation from the lake surface exceeds precipitation. The lake level is currently maintained by diversion of Bear River water into the lake during the non-irrigation period of the year. Snowmelt causes inflow streams to increase in volume each spring and increase lake levels by several feet.

The vegetation of the area around the lake is dominated by sagebrush and grasses at lower elevations and aspen and spruce trees at higher elevation. Vascular plants that grow in the lake are not common, but include Chara, Myriophyllum, and Potamogeton. Cattails and bullrushes occur near springs along the shores where water is present throughout the seasons. The fluctuation of the lake level reduces the ability of these aquatic plants to thrive in Bear Lake.

The microscopic algae in the lake is present in low amounts due to the lack of available nutrients in the water column. This low level of algal abundance supports a limited number of zooplankton species. The most common large-bodied zooplankton include Epischura and Bosmina. Small bodied rotifers are dominated by Conochilus and Keratella. Invertebrates inhabiting the sediments of the lake are dominated by ostracod crustaceans and chironomid insect larvae.

Thirteen species of fish reside in Bear Lake and four of these are found only in Bear Lake. These endemic fish are the Bonneville cisco, Bonneville whitefish, Bear Lake whitefish, and Bear Lake sculpin. Native fishes include the Bonneville cutthroat trout, Utah sucker, redside shiner, speckled dace and Utah chub. The exotic fishes are lake trout, common carp, yellow perch and green sunfish. The endemic whitefishes and sculpin rely on invertebrates inhabiting sediments for their food supply. Cisco consume mainly zooplankton from the middle of the water column. Cutthroat and lake trout are important for recreational fishing and feed mainly on a combination of small fish and large invertebrates. Rock substrates appear to be important spawning habitat for Bear Lake sculpin, Bonneville cisco, and the two species of endemic whitefish. Cutthroat trout spawn in gravel reaches of the larger tributaries. Their population is maintained by a hatchery program conducted by the Utah Division of Wildlife Resources using adult cutthroat trout taken from Bear Lake as the spawning stock. Currently lake trout populations are maintained through the stocking of sterile fish.

Many bird species use Bear Lake as feeding and nesting habitat. Western grebes frequent the open water areas of the lake and many species of waterfowl use the marsh at the north end of the lake for nesting. This marsh is an important habitat for North American migrating waterfowl. The area near Bear Lake supports snowshoe hare and pygmy rabbits, as well as other mammal species typical of the intermountain west. A number of threatened and endangered species use the Bear Lake region.

The long history of Bear Lake provides evidence of ancient climates and organisms. Sediments collected from the lake have been aged to be over 250,000 year old. Analyses of remains of plants and animals found in sediment cores indicated that Bear Lake has been intermittently connected to the Bear River during the past 30,000 years. The elevation of the lake was substantially higher 12,000 years ago during wetter, colder climate period. This evidence suggests that Bear Lake has been isolated from Bear River since 8000 years ago, and until the canal system linking the lake to the river was constructed a century ago.

# GEOGRAPHIC SETTING

Bear Lake is one of Rich County's most striking geographic vistas. The lake is used as a resource for irrigation and power generation, recreation and reflection, and functions as a unique fisheries habitat. It is located within an elongated basin between 2 active fault systems at the boundary between the Basin and Range Province and the Colorado Plateau. The lake covers more than 112 square miles and straddles the Idaho-Utah border. Approximately 20 miles long and 8 miles wide, it sits at an elevation of 5,924 feet along the northeast side of the Wasatch Range and on the east side of the Bear River Mountains. It is 208 feet at its deepest point with an average depth of 94 feet. A steep mountain face that begins its climb nearly from the water's edge mostly defines the eastern shore. The western shore rises more gradually through foothills to a high ridge. The north and south shores are natural beach bars. Beyond the bar at the north end is Dingle Swamp, whose open-water portion is called Mud Lake and is the home of the Bear Lake Wildlife Refuge. Figure 1 details the approximate location.

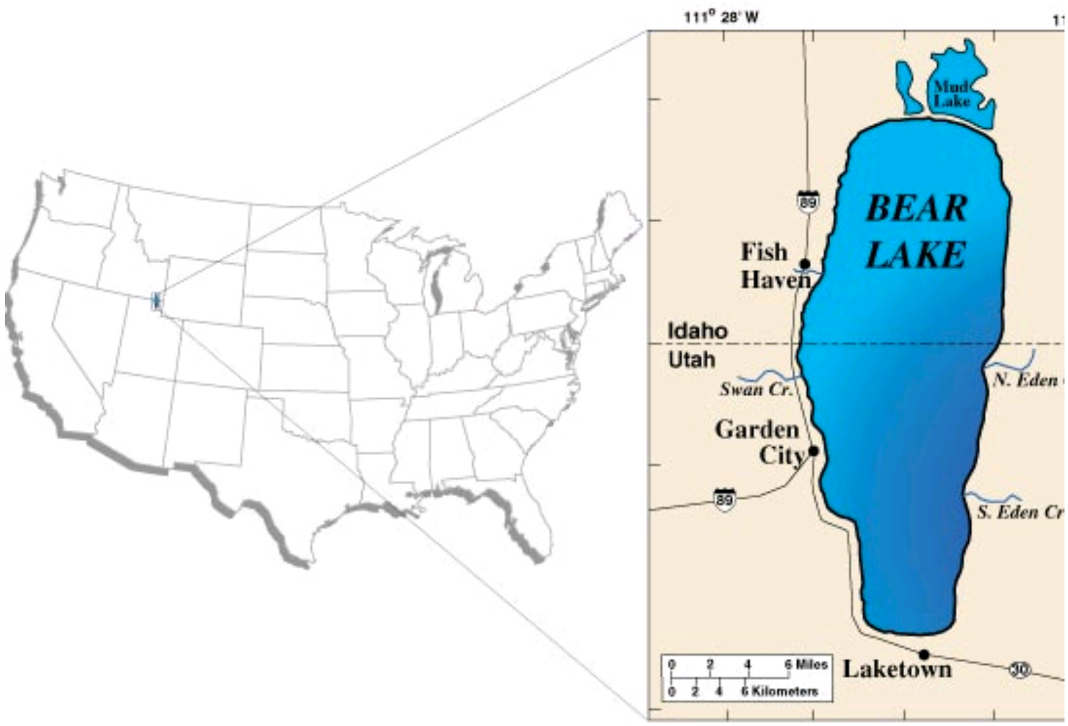



*Figure 1. Geographic Setting for Bear Lake (Denny, 2002).*

Land use in and around Bear Lake is composed of three basic types. First, the high mountain lands which are used primarily for grazing, watershed protection and some recreation. Second, the foothills which are used for grazing, dry farm crops and recreational home sites; and third, the valley lands used for irrigated croplands, pasture for native grass, hay or cattle grazing, and major residential areas.

The lake is often noted for its deep blue color resulting from high concentrations of calcium carbonate in the water, and is a popular summer tourist destination and holds some of the best beaches in the intermountain west. The lake has three marinas, several campsites, and two small tourist towns known as Garden City and Laketown.

## RICH COUNTY, UTAH

Rich County, located in the upper northeastern corner of Utah, is approximately 18 miles wide and 56 miles long. It is bordered on the east by Wyoming, on the north by Idaho (with the southern half of Bear Lake extending into Utah), on the west by Weber and Morgan counties and the Wasatch National Forest, and on the south by Summit County. The major cities and communities of Rich County are Garden City, Laketown, Lakota, Meadowville, Pickleville, Randolph, Round Valley, and Woodruff. See figure 2 for establishment date and 2000 population numbers of each community.

Rich County comprises a land area of 654,080 acres. A total of 170,583 acres (26%) are administered as public resource lands by the Bureau of Land Management; 51,835 acres (8%) are administered by the U.S. Forest Service along the western perimeter of the county; 67,695 acres (10%) are owned by the state of Utah; 362,836 acres (55%) are currently under private ownership, and some 4,376 acres (1%) are located within urban centers, road rights-of-way, and railroad rights-of-way. The principal cities include: Randolph, Laketown, and Garden City. Local economy is basically generated from agriculture, cattle, sheep, and recreation (Parson, 1996).

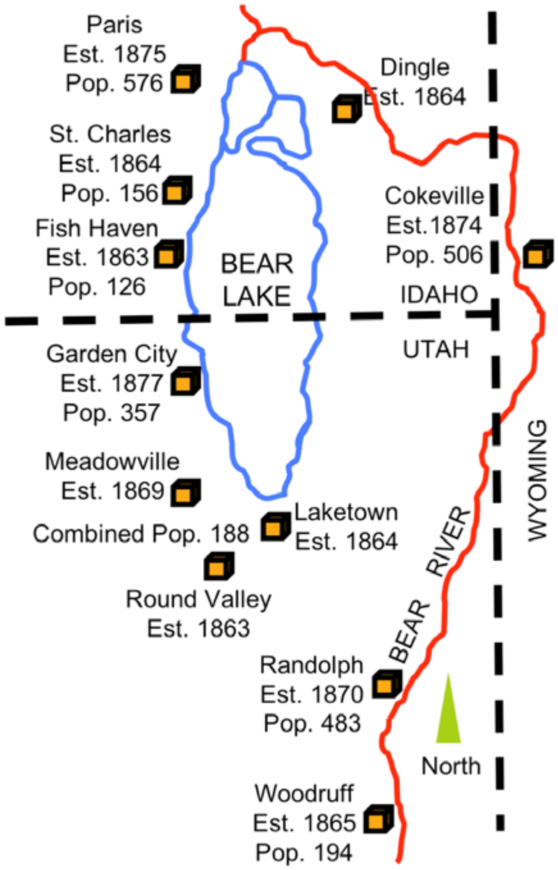



*Figure 2. Year of Establishment and 2000 Population Estimates of Bear Lake Townships (U.S. Census Bureau, 2000).*

Elevations in the county vary from a high of 9,045 feet at Cristo Peak on the western edge of the county, to a low of approximately 5,900 feet at the surface of Bear Lake. Existing land use surveys consist of 6 unique types; water (36,352 acres open water), urban land (2,304 acres in Garden City, Laketown, Randolph, and Woodruff), multiple uses (271,040 acres), recreation (2,592 acres), recreation development (3,264 acres mostly privately owned) and agriculture (373,408 acres day cropland, irrigated pastures, native grazing lands) (BLRC, 1979).

Historically the south shore areas of Bear Lake were the home of several nomadic Indian tribes. Utilized primarily during spring and summer periods, the Shoshonie, Bannock, Ute, Sioux, and Blackfoot Indian tribes favored the prime hunting and fishing of the area (Parson, 1996). It was customary for these native Americans to spend many weeks on the shores of Bear Lake trading furs, ponies, and fish with other tribes and then eventually with the white man. The Rocky Mountain Fur Company joined the fur trading rendezvous in 1826 and 1827.

Permanent settlement of the valley by “white men” was initiated by the Mormon pioneers in the 1860’s. When Congress passed the Homestead Act of 1862, Brigham Young became anxious to obtain control of the land before the non-Mormons did. Although the earliest communities were established on the north west shores of the lake, exploration for suitable town sites were being conducted at this same time in the Round Valley and Laketown area. Rich County takes its name from Mormon colonizer Charles C. Rich, who officially established the county on March 5, 1872, with Randolph as its county seat (Real Life Foundation, 2006).

*Bear Lake State Park Rendezvous Beach is named for the famous rendezvous of fur trappers and Indians held in the summers of 1827 and 1828. A thousand or more Indians and mountain men, including Jedediah Smith, attended the gatherings. There were so many campfires at the south end of the lake at these trading sessions that one observer called the area "a lighted city." http://www.stateparks.utah.gov*

Even though much of Rich County is highland, it also has fertile lowlands that can support productive farms and livestock production. Farming and livestock production have provided county residents with their livelihoods from the mid-1800’s to current times. The 2002 census of agriculture indicated that there were 509,279 acres in farms or ranches in the county with an average size of 3,772 acres. The value of livestock and crops produced was listed at $13.1 million, and was ranked first in the production of “other hay”. The census also showed Rich County as having the third largest inventory of beef cattle in the state (Godfrey, 2005).

| Rich County Demographics | | | | | | | |
|---|---|---|---|---|---|---|---|
| Water Area | 57.76 Square Miles | | | | | | |
| Land Area | 1028.53 Square Miles | | | | | | |
| Total Area | 1086.29 Square Miles | | | | | | |
| Year | 1900 | 1910 | 1930 | 1950 | 1970 | 1990 | 2000 |
| Population | 1946 | 1883 | 1873 | 1675 | 1615 | 1725 | 1961 |
| Population Density (per square mile) | 1.89 | 1.83 | 1.82 | 1.63 | 1.57 | 1.67 | 1.90 |
| Housing Units | ---- | ---- | 472 | 580 | 741 | 1859 | 2408 |
| Housing Density (per square mile) | ---- | ---- | .46 | .56 | .72 | 1.80 | 2.30 |

*Table 1. Demographics of Rich County, Utah ( U.S. Census Bureau, 2000).*

As of the year 2000 census, 1,961 people, 645 households, and 521 families were residing in the county. The population density is just under 2 people per square mile. There are 2,408 housing units at an average density of 2 per square mile. The racial makeup is 1,889 White, 1 Native American, 8 Asian, 36 Hispanic or Latino, 18 from other races, and 9 from 2 or more races. Of the 645 households in the county, 272 have children under the age of 18, 480 are married couples living together, 24 have a female householder with no husband present, and 123 are non-families. The average household size is 3.01 and the average family size is 3.44. The population is spread out with 679 under the age of 18, 141 from 18-24, 435 from 25- 44, 429 from 45-64, and 277 who are 65 years of age or older. The median age is 34 years. For every 100 females there are 103 males. The median income for a household in the county is $39,766, and the median income for a family is $44,783. Males have a median income of $34,464 versus $22,396 for females, and the per capita income for the county is $16,267. Out of the total population, 10% are below the poverty line consisting of 158 adults, 26 under the age of 18 and 12 individuals older than 64. As table 1 indicates the population has remained within one to eighteen percentage points of the current population since the early 1900’s. This stable population growth, however, is not mimicked in the number of housing units being developed in the area. This number has more than tripled in the last thirty years. This trend has been observed in all municipalities in the Bear Lake basin.

| Population of Bear Lake Municipalities | | | | |
|---|---|---|---|---|
| | 1970 | 2000 | 2004 | 2020 |
| St. Charles, ID | 200 | 156 | 145 | ---- |
| Fish Haven, ID | 120 | 195 | ---- | ---- |
| Garden City, UT | 134 | 357 | 391 | 348 |
| Pickleville, UT | 106 | 121 | 138 | 157 |
| Laketown, UT | 208 | 188 | 263 | 298 |

*Table 2. Population of Bear Lake Municipalities ( U.S. Census Bureau, 2000)*

Data from the Census Bureau indicate that the populations around Bear Lake in both the Idaho and Utah sides have remained relatively stable within the past thirty-five years, with a 32% increase overall between 1970 and 2000. As table 2 depicts the Utah State Data Guide suggests that this trend will continue with the 20% increase expected between 2000 and 2020. The areas that currently comprises the greatest increase are Garden City, Utah and Fish Haven, Idaho.

# HISTORY OF HUMAN IMPACT ON BEAR LAKE

The immediate uses of the water in Bear Lake, local surrounding streams, and the larger Bear River, were primarily for fishing and irrigation. After building a few aspen cabins, the newly settled pioneers began the task of constructing irrigation canals. Within its valley, the Bear River and its tributaries water over 50,000 acres of land in Rich County. The largest irrigation sources are Big Spring and Swan Creek. Settlers in Laketown, Round Valley, and Meadowville continued to construct a network of canals still being used today; these included the Crawford and Thompson Canal, the Beackwith Canal, and the Chapman Canal (Parson, 1996).

Between 1885 and 1891 the Randolph/Woodruff Canal was completed which, as of 1996, still irrigates nearly ten thousand acres. The partnership with the federal government after the Newlands Reclamation Act in 1902 allowed the construction of reservoirs to improve irrigation systems. Big Creek Reservoir was built in 1936 followed by a dam in the Woodruff Narrows on the Bear River.

*The water held in Bear Lake helps irrigate over 150,000 acres, or 234 square miles, of farmland and raises $45 million in crops each year. The most senior water rights holder is the Bear River Canal Company in Box Elder County (Hayes, 2002)*

After irrigation, the second use of water in the valley was for waterpower. The first gristmill was completed in 1865, and the first water-powered saw mill was built in 1886. Electricity, from a small hydropower plant, on Swan Creek came to the area in 1912. New development in the area occurred with the completion of the federal surveys in the late 1870's. It was then acknowledged that the Bear River Basin was part of three territories; Utah, Idaho, and Wyoming; and that the lake lay both in Idaho and Utah territories. The transcontinental railroad passed through the basin during this same period and brought significant numbers of non-mormon settlers into the area. As the easily irrigated land was appropriated, the irrigation of new land required more sophisticated construction techniques and a great increase in the amount of water to be used.

Several large canals were built in the basin below Bear Lake around the turn of the century. Experiments in raising beets proved highly successful and the Utah-Idaho Sugar Company bought stock in several existing canal companies that were having financial problems. The Utah-Idaho Sugar Company bought rights to the Bear River for power production as well as for irrigation. In 1912, Utah Power and Light Company purchased the hydroelectric property and the accompanying water rights insuring virtual control of the Bear River waters below Bear Lake.

The Bear River has not naturally entered Bear Lake for roughly 12,000 years. Bear River waters flowed into Mud Lake, but were separated from Bear Lake by a natural sand bar. In the late 1800's irrigators wishing to use the lake as a storage reservoir conceived a plan to divert the Bear River into Bear Lake. In 1911 the Telluride Power Company completed a water diversion on the Bear River and began water diversion into Mud Lake via the Dingle canal. In that first year, 40 million cubic yards of water were diverted and stored for irrigation releases (USU Special Collections, 1995).

The Utah Power and Light Company secured its control in 1912 when it purchased the Telluride Power Company. In 1914 the Telluride and Utah Power Company completed three canals between the Bear River and Bear Lake. Utah Power expanded the diversion operation by building Steward Dam on the Bear River and Lifton Pump station at the Bear Lake outflow. These structures were completed in 1916 and 1917 respectively and allowed for more diversion and elimination of reliance on natural flows out of Bear Lake. The Bear River water enters via a canal that enters Mud Lake and then Bear Lake. The mixed lake and river water exits just west of Mud Lake with the help of Lifton Pumping Station. The purpose of the Rainbow and Telluride canals was to more efficiently divert Bear River water through Dingle Marsh into Bear Lake. During dry years, the Utah Power and Light Company can drain 20 vertical feet off the top of the lake to produce electricity and irrigation water downstream. Hydroelectric power is produced when the water held in the lake, along with the natural flow of the Bear River, passes through 5 down-stream plants. These five plants provide about 94% of the hydroelectric

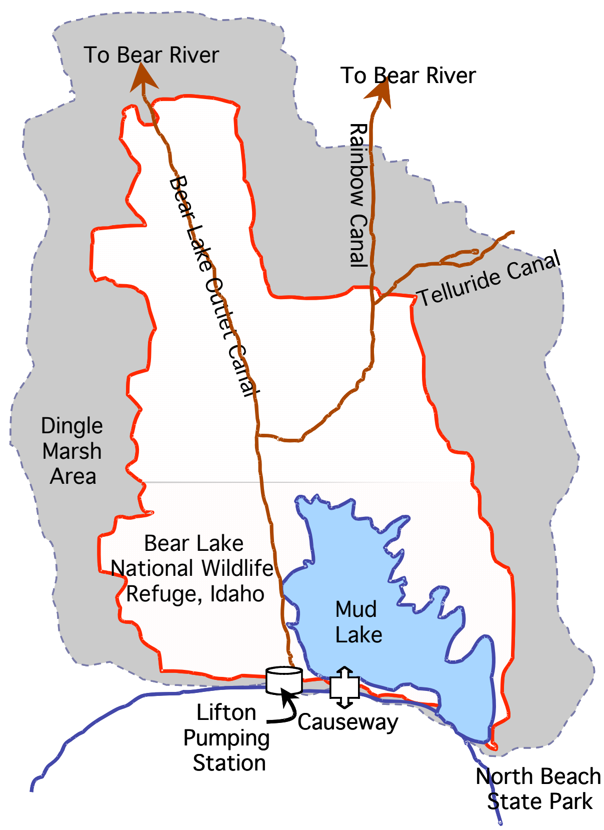
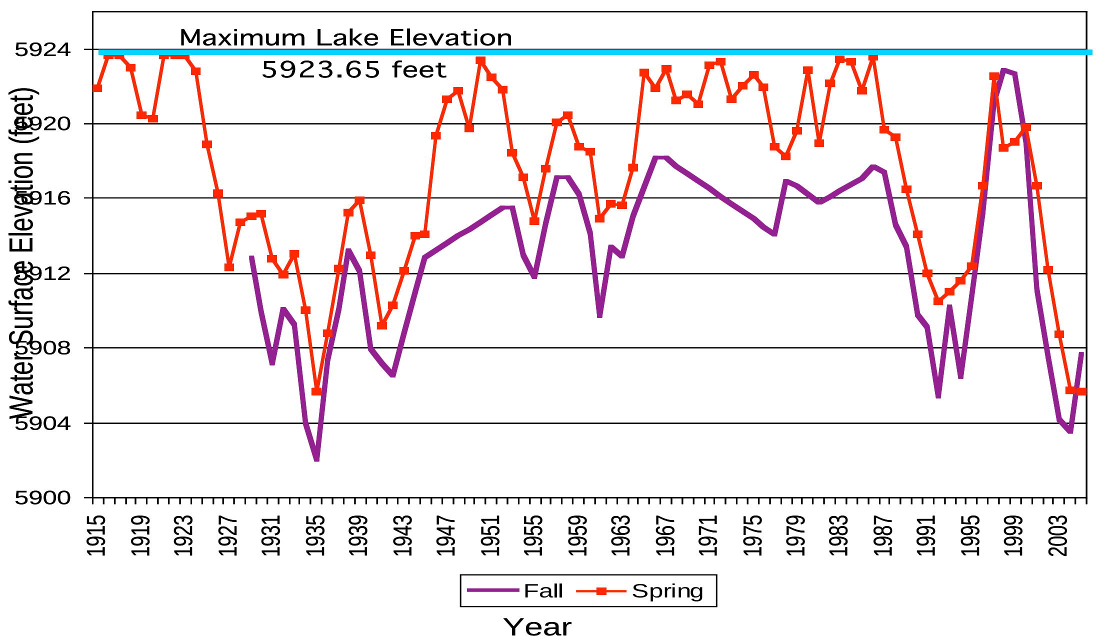



*Figure 3. Dingle Marsh and the Utah Power and Light Canal System (Modified from Sigler, 1972).*

generating capacity in the Bear River Basin. The Bear River Compact controls the amounts of water for power generation and irrigation projects. Figure 3 shows location and configuration of the canal systems in Dingle Marsh, Idaho.

Water levels of Bear Lake have fluctuated annually since use as a reservoir began (Graph 1). 2.8 billion cubic yards of water were diverted from the Bear River into Bear Lake during the years of 1975 and 1984. During the same time period low and high annual Bear River inputs were 15.8 and 450 million cubic yards for 1977 and 1980 respectively (Lamarra, 1986). Water diverted from the Bear River account for the majority of the waters entering Bear Lake (Lamarra, 1986). The remaining water enters from streams in the endemic (all surface waters except Bear River) Bear Lake drainage, in-lake springs or through direct precipitation on the lake itself.




*Graph 1. Utah Power Water Levels Reported at Lifton Pump Station 1915-2005. Flat Line Indicates "Full Pool" at 5923.65 Feet Above Sea Level.*

During the 40 years following completion of the Lifton complex extensive litigation occurred to decide the water allocations and distribution of Bear River waters. In 1958 the Bear River Compact was finalized and the formation of the Bear River Commission was enacted to manage water use along the entire length of the Bear

River. The Bear River Compact is a collaborative effort by the states of Utah, Idaho, and Wyoming that provides for the distribution of water on the Bear River and a reserved portion of the storage capacity in Bear Lake. (See appendix A for full text of compact). Negotiators recognized the extreme high and low water elevations that can occur in Bear Lake and measures were passed to mandate certain actions. Among other stipulations the Compact reserved all Bear Lake waters below 5,914.61 ft to be maintained for irrigation and that water could not be released for the sole purpose of hydropower generation (Bear River Compact, 1963). Water levels are not allowed to go above historic high water elevation of 5923.65 feet or below the historic low of 5902.00 feet. Since the mid-1960's, Utah Power and Light Company has operated Bear Lake at an elevation of 5918 feet which satisfies most recreational users and provides a good holdover storage for irrigators (BLRC, 1997).

*Utah Power and Light dates back to 1881, when Salt Lake City became the fifth city in the world to have central station electricity. In just 10 years, UP&L grew to serve 205 communities and 83,000 customers. PacifiCorp was formed in 1984, when its coal mining and telephone businesses grew into full-fledged enterprises. In 1989, it merged with Utah Power and Light, and continued doing business as Pacific Power and Utah Power. In 1999, PacifiCorp merged with United Kingdom-based Scottish Power. PacifiCorp operates as Pacific Power in Oregon, Washington and California; and as Rocky Mountain Power in Utah, Wyoming and Idaho. The company was acquired by MidAmerican Energy Holdings Company in 2006.*

PacifiCorp merged with Utah Power in 1989 and currently controls the operation of the Bear Lake portion of the Bear River Compact. The lake is operated with 2 main goals: water storage for irrigation and flood control along the Bear River. Power generation is considered a by-product of the 2 main goals (UDWR, 2005). Utah Power operates 5 on-river hydropower stations along the Bear River below Bear Lake, and associated with 3 of those facilities are small storage reservoirs. Those small storage reservoirs were licensed to generate 115.9 MW (mega watts) in 2000 (UDWR, 2005).

The Commission does not get involved in the operation of the river unless conditions exist that trigger provisions of the Compact. Rights to direct flow in the 3 administrative diversions of the river is administered by the contributor state under state law. The divisions are defined as a) Upper division – that portion of the river from its source to the Pixley Dam near Cokeville, Wyoming; b) Central division – that portion of the river from Pixley Dam to Stewart Dam just northeast of Bear Lake and; c) Lower division – that portion of the river from Stewart Dam to the Great Salt Lake, including Bear Lake (Bear River Compact, 1963). General watermasters are appointed by the respective state engineers to operate the river reaches and canal diversions in their region.

Article XIII of the Compact allows the Commission to review the provisions of the Compact every 20 and to propose amendments. In 1977 an amended compact was signed that allowed better defined citizen rights, additional storage rights for all 3 states, and included groundwater development as a part of the allocations. In November 1997, the Commission completed the next 20-year review and no amendments were proposed.

Over time the number of farms around the lake has begun to decrease and the rural non-farm population has increased. Agriculture in the area is slowly giving way to recreational and housing developments. For this reason, in 1973, the Bear Lake Regional Commission was formed. The purpose of the Commission is to provide an organization to administer and plan the development of the Bear Lake surrounding areas, to focus on lake conservation, and to provide orderly growth and recreational opportunities within the region.

This group, along with PacifiCorp and other downstream water users, reached an agreement titled the "Bear Lake Settlement Agreement" in 1995. The agreement provides, among other things, that starting at a lake elevation of 5914 feet, downstream users will restrict their call for Bear Lake stored water. This reduction in use will add additional stabilization of lake levels and encourage conservation within the provisions of the Compact and the parameters of the states (BRLC, 1997).

## PLANNING AND ZONING AROUND THE LAKE

Communities in the Bear River basin are presently encountering various intensities of growth and development due to new residential, commercial, and agricultural development. In general, the development is distributed unevenly throughout the basin with much heavier concentration occurring south of Grace, Idaho and continuing into Garden City. Around the Bear Lake area, development is sprawling outward from the lakeshore and up the sides of the foothills. The west and south shores are primarily privately owned with summer home development, while the east shore is mostly state owned with multiple access points. See figure 4 for development around Bear Lake. The residential development is expressed in both permanent housing and an equal amount of seasonal (summer and winter) residential construction. The commercial and service growth in the area is directed more toward the tourist/ recreational growth of the region as opposed to support services for either the agricultural or full residential activities (Toth, 2005).

Culinary water sources for the communities of Laketown, Pickleville, and Garden City are supplied by springs in the basin. Swan Creek Spring provides water not only to Garden City but also the area along the lakeshore from Garden City to the Idaho boarder (BLRC, 1979).

For the rural communities of Laketown and Garden City, whose economies have revolved around farming and ranching, growth is becoming more dependent upon tourism, recreation, wildlife habitat, and other public purposes. Planning for the future in the face of a changing and diverse public perception depends upon their ability to merge traditional uses with new economic opportunities.

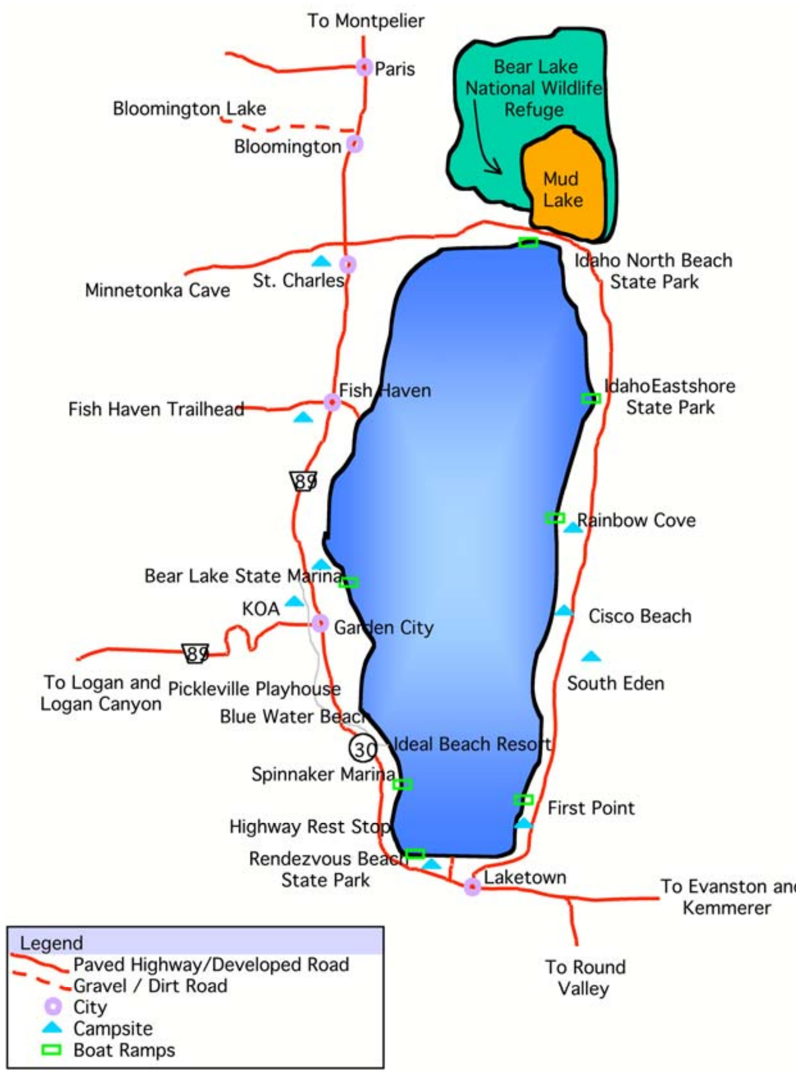



*Figure 4. Bear Lake Development Areas (recreated from Lamarra, 1997).*

Andrews and Dunaway conducted a survey to assess the current and future development of Bear Lake County, Idaho and Rich County, Utah. The objective of the study was to determine possible sources of conflict over land management practices and water use. Interviews and mailed questionnaires were assessed to identify the greatest problems facing property owners in the Bear Lake area. The greatest problems expressed by local farmers and year round residents were too many recreationists and pollution of the lake. Many of the property owners stated they were concerned about high property taxes forcing them out of the area. Absentee property owners reported being concerned with increasing pollution of the lake, high sewage costs, and fluctuating water levels. With respect to changing land uses, farmers valued having the land use remain as it is with very little development while non-farmers favored more business coming into the area.

# ORGANIZATIONS AND AGENCIES IN BEAR LAKE MANAGEMENT

There are two major organized private interest groups in the Utah side of the Bear Lake area, Utah Power and Light Company and the Bear Lake Home Owners Association. Several agencies concerned with the water and the immediate land area around the lake exist at the federal level. The U.S. Fish and Wildlife Service manages the National Bird Refuge located in a swamp just north of Bear Lake. The Environmental Protection Agency is concerned with maintaining the water quality of the lake and the U.S. Army Corps of Engineers has jurisdiction with respect to construction below the 5924-foot elevation level of the lake. Utah State agencies involved with the lake include the State Parks and Recreation Division, Division of Wildlife Resources, Forestry, Fire and State Lands, State Land Planning Commission, and State Board of Health.

At the local level several county agencies have jurisdictions in the Bear Lake area as well as the towns near the lake. The Rich County Commission enumerates the requirements for building near the lake and controls the shoreline ordinances. The only 2 incorporated towns that are on the immediate shore, Garden City and Pickleville, have adopted these ordinances.

Regionally there exist several groups. The Bear Lake Regional Commission is a bi-state, bi-county organization that coordinates planning efforts in both Utah and Idaho states. The Commission was formed to address problems relating to preservation of the lake and provide orderly growth and development within the region. Designated by the Secretary of Agriculture October 15, 1966, the Bear River Resource Conservation and Development Council, Inc., is a non-profit organization that addresses conservation and development issues in Oneida, Caribou, Franklin, and Bear Lake Counties in Idaho as well as Box Elder, Cache, and Rich Counties in Utah. The Bear River RC&D area includes nearly the entire Bear River basin. Organized in 1994 and headed by Merlin Olsen, the Bear Lake Watch is a local group with the goal to assure that the interests of public are served and to protect and restore the environment and waters of Bear Lake.

| | |
|---|---|
| Utah Power and Light Company | http://www.utahpower.net / http://www.pacificorp.com/ |
| Utah Division Wildlife Resources | http://wildlife.utah.gov/ |
| U.S. Fish and Wildlife Service | http://www.fws.gov/ |
| Environmental Protection Agency | http://www.epa.gov/ |
| U.S. Army Corp or Engineers | http://www.usace.army.mil/ |
| Utah State Parks and Recreation | http://www.stateparks.utah.gov/ |
| Utah State Board of Health | http://www.health.utah.gov/ |
| Rich County Commission | http://www.richcountyut.org/index.html |
| Bear River RC and D Council | http://www.bearriverrcd.org/ |
| Bear Lake Regional Commission | http://www.bearlakeregionalcommission.org/ |
| Bear Lake Watch | http://www.bearlakewatch.com/ |

*Table 3. Major Organizations in Bear Lake Management and Web Addresses.*

## RECREATION

Bear Lake has a long history of recreation and tourism. Activities such as water-skiing, swimming, and sailing are popular during the summer seasons. In the winter snowmobilers and ice anglers are drawn to the area. In January, fishing for the rare Bonneville cicso is a major event for local fishermen and tourists. No other lake in the continental United States offers such an opportunity.

Recreational water use continues to grow in the area. From 1959 to 1998, the number of registered boats in the state multiplied just over nine times to a total of 76,346. Numbers have decreased 20% to 61,345 in the year 2006. The number of fishing licenses sold for the same period increased nearly three times. Expectations are that both will continue to grow at these same rates. According to surveys done by the Division of Parks and Recreation, 95% of those boating at Bear Lake were from Utah. The surveys also reveal that, although the number of boats grew steadily, the majority of boaters do not yet consider the lake overly crowded (Utah Division of Parks and Recreation, 2005).

*Cisco Beach is known for excellent inland water scuba diving opportunities. The rocky bottom and the steep drop off close to shore make this location a favorite of divers from the Tri-State area. Two diving areas have been marked and designated for this activity. The temperature in Bear Lake on the surface is in the low to high 60's in the summer. Below the thermocline, at around 35 feet, temperatures drop to 40˚F. Bear Lake sculpin, and other endemic fish, can frequently be observed by diving at this level*

Three state-owned facilities provide boating, camping, and picnicking. Bear Lake has approximately 50 miles of shoreline with 14½ miles open to public access. These access points include three state parks, state lands (east shore), and state highway right-of-ways. There are seven major boat-launching facilities, six of which are open to the public. (See figure 4). Bear Lake State Park Marina has 305 boat slips and a 5-lane boat ramp, while Idaho's North Beach has 2 boat unloading ramps and sandy beaches.

The main mode of transportation in the Bear Lake Basin is by private automobile. No bus or passenger train services operate in the basin. The nearest airport is at the Bear Lake County Airport located approximately 3 miles east of Paris. U.S. Highway 89 enters the basin from Logan Canyon on the west of the lake and from Montpelier and Paris from the north. This highway is one of the most scenic routes to the Yellowstone and Teton National Parks in Wyoming. As a result, much of the summer traffic is passing through to other points of destination. The traffic increases 230% to 360% during the peak month of July as compared to the low month of January. Highway 16 and 51 join at Sage Creek Junction and enter the basin at Laketown on the southern end of the lake (Lamarra, 1986). The following figure enumerates the traffic statistics collected by the Transportation Monitoring Unit and developed and analyzed by the Traffic Analysis Section of the Utah Department of Transportation. Each counting station records the annual average daily traffic on road sections. These permanent stations have provided traffic statistics since the early 1980's. Figure 5 presents data for the years between 2000 and 2004.

The annual average daily traffic on state and local highways has continued to rise despite the construction on highway 89 from Logan to Bear Lake. Construction began in the summer of 1999 and will continue until winter of 2006. Traffic is often reduced to one lane with several sections closed during non-peak hours. Table 4 shows the number of visitors that have been counted at the Bear Lake State Park per month for several years.

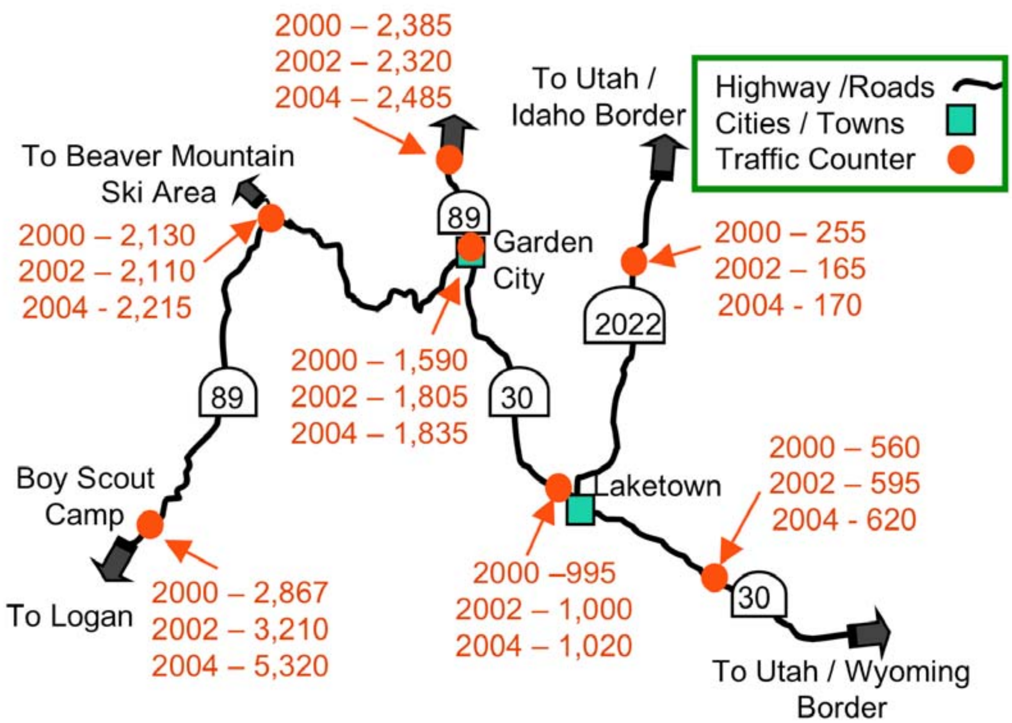



*Figure 5. Average Daily Traffic Counts on the Highways Around Bear Lake Between 2000 and 2004 (UDOT, 2006).*

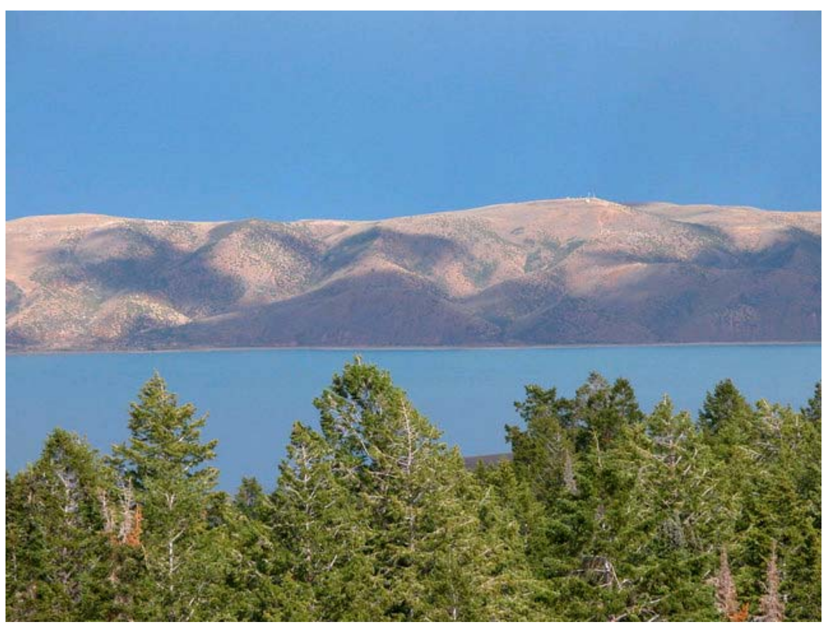
| Visitors at the Bear Lake State Recreation Area | | | |
|---|---|---|---|
| | 1980 | 1990 | 2002 |
| January | 17,131 | 1,614 | 3,282 |
| February | 2,198 | 764 | 2,718 |
| March | 1,792 | 1,205 | 2,534 |
| April | 9,961 | 2,783 | 3,025 |
| May | 18,514 | 4,042 | 15,347 |
| June | 30,799 | 24,151 | 19,117 |
| July | 57,985 | 50,417 | 115,714 |
| August | 42,522 | 40,975 | 90,566 |
| September | 21,196 | 29,507 | 48,231 |
| October | 5,064 | 3,612 | 5,878 |
| November | 1,564 | 494 | 1,630 |
| December | 1,879 | 641 | 2,133 |
| Total | 210,605 | 160,205 | 310,175 |

*Table 4. Visitors Per Month at the Bear Lake State Recreation Area as Reported by the Utah Department of Natural Resources, Division of Parks and Recreation, 2005.*

## *RECREATION HISTORY*

Lakota Bear, purchased around 1913, became the first successful resort with log cabins and a heated pool. About the same time the Ideal Beach Amusement Company began operation with cabins, concessions, dance pavilion, first class restaurant, and rowboat or canoe rentals. In the 1970's the area around Bear Lake experienced a recreational boom. Five new enterprises appeared along the lake including the Sweetwater Resort. This resort was the first to develop winter recreation by offering snowmobile rentals, cross-county trails, and sleigh and toboggan runs. Through the 1950's and 1960's the Rich County area felt an increased demand for recreational pursuits. The west shore of Bear Lake became interspersed with private cabins, motels, and the new Blue Water Beach. As recreational activity steadily increased, state and federal agencies began taking an interest in the region. Rendezvous Beach was designated a state park in the summer of 1978 and had entertained over 80,000 people in its first season (Parson, 1996). Rendezvous State Park complemented the already existing Bear Lake Marina located north of Garden City. The state constructed the marina in 1965-66 to accommodate all sizes of boats and, with a recent expansion, to remain usable to lake elevations at a low of 5,903 feet. The parks on the eastside of the lake, First Point, South Eden, Cisco Beach, Rainbow Cove, and North Eden, were obtained through a number of transactions from 1962 through 1987 (Utah Division Parks and Recreation, 2005).

The Utah Power and Light Company's capability to raise and lower the reservoir lead to erratic lake levels that caused resort visitation numbers to vary. High levels brought high-demands while low levels yielded a drastic reduction. In 1955 the joint compact among Utah, Idaho, and Wyoming was signed into law by President Eisenhower to address this problem. The Bear River Compact would be used to provide for efficient use of the water while promoting multiple purposes. Early in 1973 the Bear Lake Regional Commission was created. It was formed to assist in addressing problems related to impacts of growth in and specifically around Bear Lake.

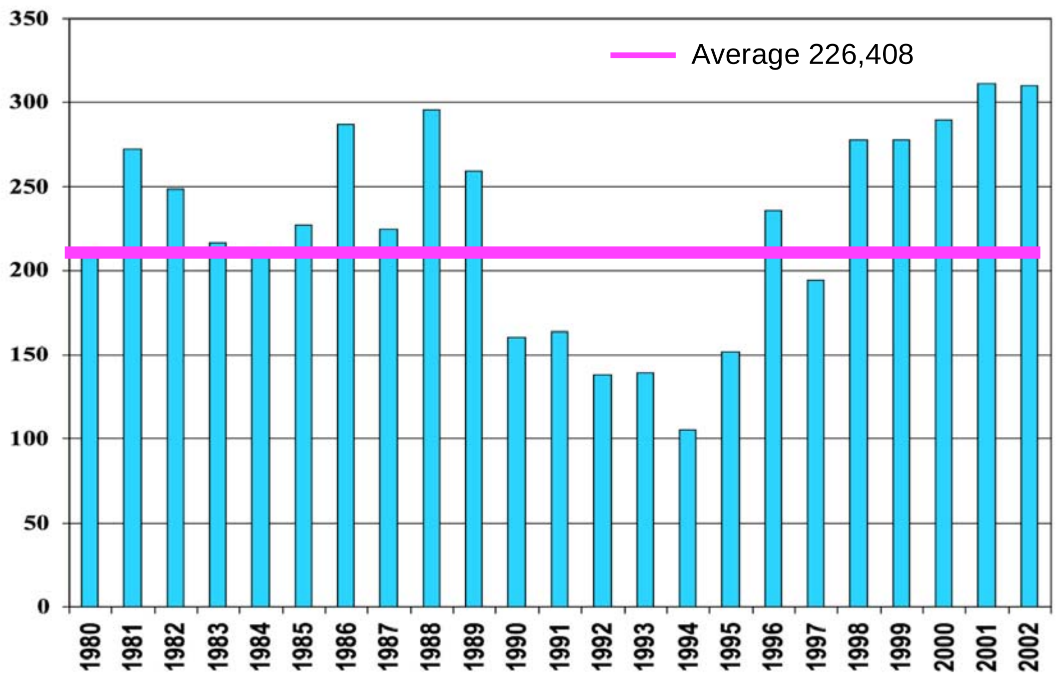


**Bear Lake Looking East**

*Photo from: http://www.orneveien.org/adventure/bearlake/02.htm*

## *ESTIMATES OF RECREATION USE ON BEAR LAKE*

Bear Lake State Park's annual visitation has been trending upwards since 1990, despite dips in visitation in 1994 and 1997. Visitation increased 94% from 1990 to 2002. Most visits to Bear Lake occur between July and September, with 34% of the yearly total in July (Utah Division Parks and Recreation, 2005).




*Graph 2. Number of Visitors at the Bear Lake State Park Between 1980-2003 (Utah Division of Parks and Recreation, 2002).*

A visitor survey conducted at the Bear Lake State Park administered between May 21 and September 2, 2002 summarized the following conclusions:

►The majority of respondents, 69.3%, report that Bear Lake was their only destination.

►According to the survey the Bear Lake Marina is the most visited site (72.1%), followed by Rendezvous Beach (35.1%) and Cisco Beach (15.2%).

►Over half of respondents stayed two of more days (67.5%) while 27.6% stayed one day or less.

►More than 70% visited Bear Lake more that 2 times in the last year.

►16.8% of respondents visits the lake alone or with one other person. Groups with 3 to 10 members comprise 54.9% or respondents, and groups with more than 10 accounts for 26.1%.

►Over 75% of groups contained children under the age of 18 and in 54.4% of the cases the group was family.

►Respondents chose swimming (58.8%), boating (57%), and sunbathing (55%) as the top 3 activities with camping (37.4%) and picnicking (35.4%) close behind.

►Most respondents (80.4%) were residents of Utah.

**Bear Lake Marina**
*Photo from: http://www.wildlife.utah.gov/blueribbon/waters/bear_lake.html*

The Bear Lake valley is noted for its hunting opportunities. Hunters return year after year because of the abundance of sage grouse, ruffed grouse, blue grouse, and big game animals such as mule deer, elk, and moose.

Riley (1966) found that during the hunting season 97.5% of the visitors to Bear Lake reside in Utah, Idaho, or Wyoming with 78.1% of those living in Utah. Additional findings conclude that the majority of hunters are between 18 and 50 years of age with most (33%) falling in the 36-50 year age range. Of the hunters surveyed 80% are male, 98% married, and in a group consisting of 2-4 individuals

(70% of the time). A full 95% of those surveyed had at least one prior visit to the area and all of them said they definitely planned to visit the area again.

Fishing activity is also rising in popularity at Bear Lake. Creel surveys have been conducted on Bear Lake since 1973 to estimate angler pressure as well as catch and harvest by species information. Total angler pressure in the Bear Lake for the 12 month creel period in 2002 was estimated at 66,645 hours. This is a 25% increase from the 1999 creel count of 53,046 and a 42% increase from the 1996-1997 creel count of 27,711 (Tolentino, 2002). Harvest estimates indicated that 37,000 fish were caught and 23,400 of those were harvested (see table 5). Most angling hours were directed at the 2 trout species (S. Tolentino personal communication). Some anglers target the whitefish species, especially during winters when the lake is ice capped, and during January when cisco fishing is active. Yellow perch are a common game fish in the U.S., yet in Bear Lake they are sparsely distributed and rarely reach catchable lengths. The customary Cisco harvest takes place on the lake's east shore every January and has drawn over 8000 participating anglers consistently since before 1990. Most of the fishing takes place on the Utah end of the lake.

Consistent patterns throughout years illustrate weekend angler pressure as higher than weekday angler pressure at an average rate of 4 weekend anglers to 3 weekday. Throughout the year the estimated angling pressure during winter months, December through March of 2002, was nearly equal to the pressure observed during the summer months of May through August. Winter fishing was noted to increase substantially in years when the lake freezes over allowing for ice fishing. The highest month of weekend fishing was February while the highest month of weekday fishing pressure was May.

During the 2002 creel census, anglers reported releasing 23,461 fish and keeping 37,146 fish. This means 63% of the fish caught are harvested. Whitefish is the species caught most often (14,411) followed by cutthroat (10,053) and Cisco (8,825). These numbers were positively influenced by the Bonneville cisco that have a daily limit of 30 fish, all of which are typically harvested for bait fishing at other times of the year. Table 5 illustrates the number of fish caught and the number of fish harvested during the year 2002.

| Catch and Harvest Estimates for 2002 | | | | |
|---|---|---|---|---|
| | Catch | Harvest | Percent Of Catch Harvested | Percent Change 1996-1997 (Catch) |
| Cutthroat | 10,053 | 4,112 | 41 | 13% Higher |
| Lake Trout | 3,818 | 2,153 | 56 | 6% Lower |
| Whitefish | 14,411 | 8,332 | 58 | 375% Higher |
| Cisco | 8,825 | 8,825 | 100 | 11% Lower |
| Yellow Perch | 13 | 13 | 100 | 86% Higher |
| Other | 26 | 26 | 100 | 79% Lower |
| Total | 37,146 | 23,461 | | |

*Table 5. Catch and Harvest Estimates per Species For Year 2002 ( Utah Department of Natural Resources, Division of Wildlife Resources, 2002).*

Boat and ice anglers made up the majority of angler hours spent on Bear Lake in 2002. Anglers fishing from boats made up over 54% of the total estimated fishing pressure while ice fishing accounted for 30% followed by shore fishing at 16%. Further analysis revealed that 90% of the anglers fished on the Utah side of the lake. These percentages are very comparable to past creel surveys (Tolentino, 2002).

Bear Lake has been designated a Blue Ribbon Fishery by Blue Ribbon Fishery Advisory Council (BRFAC, 2006). Selection as a Blue Ribbon Fishery requires demonstration of a water bodies ability to support a self sustaining, fishable population, that is accessible to the public, has good water quality and unique or desirable fish species. Bear Lake meets all of these conditions. Designation of being a Blue Ribbon Fishery allows access to funds and other layers of support in maintaining the health and well being of a water body. In October 2005 funding released to Bryce Nielson by BRFAC built four artificial reefs north of the Bear Lake

State Parks Marina. These reefs were made of local rock barged to waters 33 feet deep and dropped in piles. The reefs were designed to augment the productivity and spawning opportunities for endemic fishes seen on the natural rock outcropping north of Gus Rich Point in the southwest portion of the lake. Within a week fish were observed using these reefs.

*Mission statement of the Blue Ribbon Fishery Advisory Council: "To identify, enhance and protect those Utah waters and their watersheds that provide, or have the potential to provide, Blue Ribbon quality, public angling experiences for the purpose of preserving and enhancing these valuable economic and natural resources" (http://www.wildlife.utah.gov/blueribbon/mission.html).*

The popularity of snowmobiling as a winter recreation activity in the basin has increased dramatically. A survey conducted by Utah State University in 2001 found that over 35% of Utah snowmobilers prefer to use the Hardware Ranch, Monte Cristo, and Logan Canyon Area, which include the areas around Bear Lake, to any other one place in the state. This trend is expected to continue (McCoy, 2001).


**Snowmobiling the Bear Lake Valley**
*Photo from: http://www.bearlake.org/snowmobil.html*

## Recreation Sites on Bear Lake

The 70,000 acres Bear Lake water provides opportunities for first-rate boating, swimming, sailing, water-skiing and wakeboarding. Numerous public boat ramps are positioned around the lake for launching boats. Personal watercraft, such as jet skis and waverunners, can be rented at the marina and on the beach. Over 500 campgrounds are dotted around the lake offering a range of sites, from tent to full hook-up with electricity, culinary water, and showers. Picnick tables and restrooms are available at the state park beaches. Utah and Idaho are connected by hundreds of miles of backcountry trails for all levels of all terrain vehicles (ATVs). The Shoshone ATV Trail System and the surrounding canyons make for a challenging ride. Hiking, cycling, and mountain biking opportunities are abundant and offer acres of trails through mountain wilderness. Trails include the Bear Lake Scenic Bike Trail, a 4.2 mile paved trail from Harbor Village to Ideal Beach as well as the 45-mile paved roadway that encircles the lake.

You can golf 3 seasons of the year in the Bear Lake Valley: spring, summer and fall. The golf courses are located on western hillsides overlooking the lake.

***Jet Skis and Wave Runners are Popular Water Fun on the Lake***
*Photo from: http://www.utah.com/stateparks/bear_lake.htm*

Bear Lake Marina is a well-developed boating facility with 176 slips that can be rented by day or season. It has an adjoining campground, a sheltered harbor and launching ramp, sanitary disposal station, rest rooms, and several concessionaires.

Bear Lake Rendezvous Beach is on the south shore near Laketown and provides 1.25 miles of wide, sandy beaches for camping, picnicking and watercraft activities. This beach is popular for large groups and is the site of the annual Mountain Man Rendezvous. Rendezvous' four campgrounds, Willow, Birch, Cottonwood, and Big Creek, contain a total of 178 campsites.

**Bear Lake at Sunset**

*Photo from: http://www.thewanderingwoods.com/BL/a5bl401.jpg*

First Point, found on the southeast shore, offers primitive campsites with a small boat ramp and toilet facilities. South Eden has drinking water, primitive campsites, 2 group pavilions and toilet facilities. Rainbow Cove has a boat ramp, group fire pits with grills, dispersed primitive campgrounds, and toilet facilities. Cisco Beach is famous for its midwinter fishing with dip nets for Bonneville Cisco. For a week to ten days in January the small fish come close to the rocky shore to spawn and the fisherman wade waist-deep into the icy water to scoop them up. North Eden on the east side is the most primitive camping area. It offers 2 group pavilions, 2 toilets, and fire pits with grills.

The largest and most developed recreation complex on the lake is Sweetwater, located in the southern end of the lake. Sweetwater Corporation has a resort complex on the shore of the lake that contains 150 condominiums, a convention center, 2 restaurants, and several recreational facilities. The vast majority of Sweetwater property owners are absentee owners and visits seasonally.

## GEOLOGIC HISTORY

For roughly 500 million years, during much of the Paleozoic and Mesozoic periods, the Bear Lake Basin was inundated by an inland sea. This sea would retreat and then advance leaving limestone and sandstone deposits scattered around the valley. This abruptly changed during the Laramide Revolution some 70 million years ago when the land experienced violent earthquakes that buckled the surface and forced the sea bottom upwards to 20,000 feet. Sea bottom limestone was now in direct contact to quartzite layers that had been formed millions of years earlier (Parson, 1996). This period created the present-day landscape with evidence of the over thrusting evident along the cliffs surrounding the basin and these forces continue to shape the land even today. Bear Lake was formed 150,000 years ago and extended as far north as Pescadero, Idaho. Most of the lake was shallow with deeper water impounded at the southern end of the valley. Although prehistoric Lake Bonneville covered much of Utah during this period, it never actually connected to Bear Lake but evidence suggests it was as near as 30 miles to the west. During this time the outflow from Bear Lake feed into Lake Bonneville. Concentric bars found at Ideal Beach and Garden City suggest the shoreline of the lake reached an elevation near 5948 feet before dropping to the current elevation of 5924 feet (Williams, 1962). Faulting along the east and west shores during the

Lifton episode approximately 8,000 years ago resulted in the lake occupying its present position and configuration.  Figure 6 shows lake bathymetry.

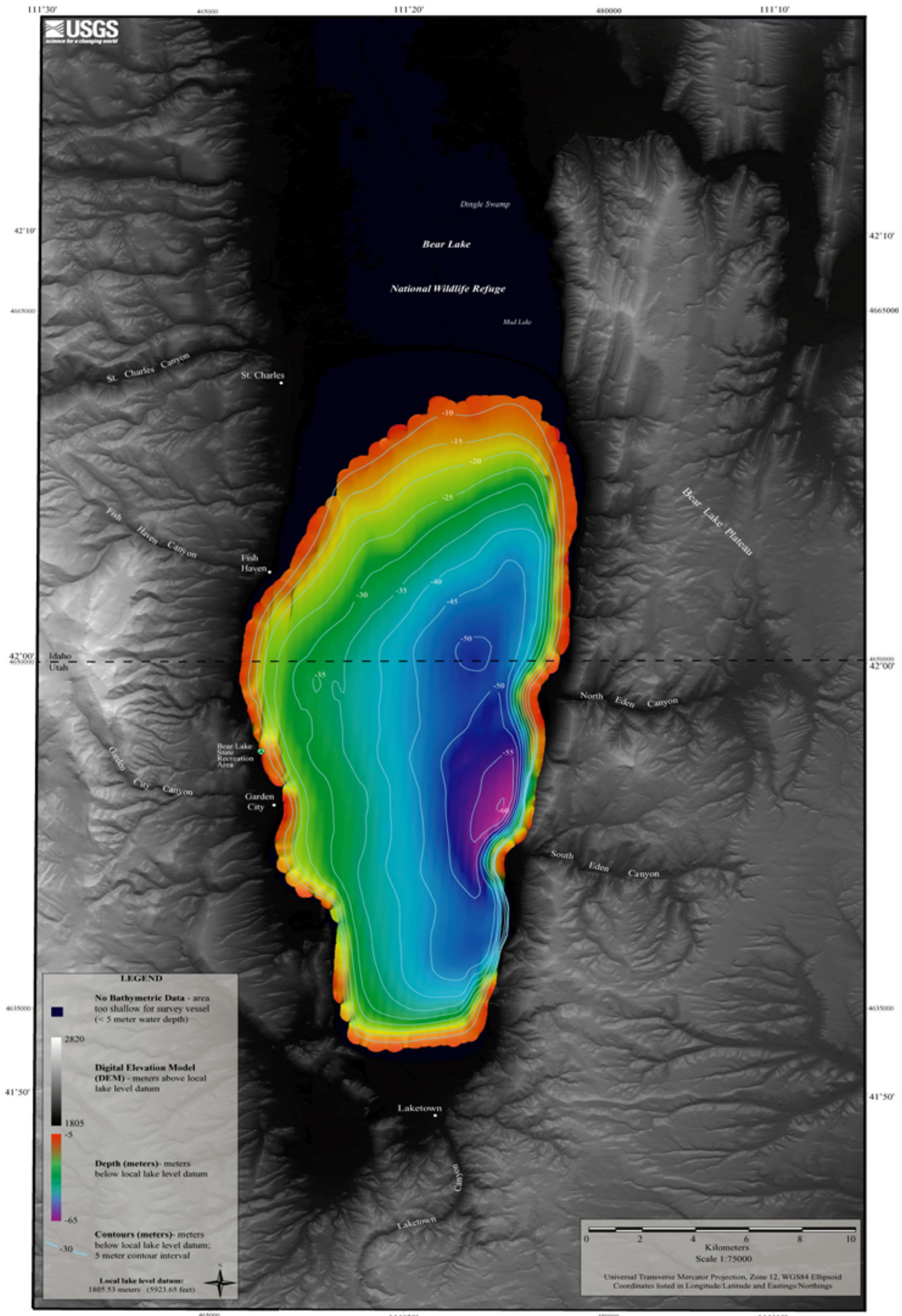



*Figure 6. Bear Lake Bathymetry. Depth is more shallow in the outer orange region with deepest area denoted in pink area near the east shore (USGS http://pubs.usgs.gov/of/2003/of03-150/html/FIG7.HTM, 2003).*

The Bear Lake Basin is composed of a wide range of geological formations from unconsolidated lacustrine, deltaic and alluvial deposits to consolidated limestone, dolomite, quartzite and sandstone deposits. Unconsolidated deposits are generally located in the valley floor with the consolidated deposits situated at elevations above 6,000 feet (Kaliser, 1972).

## SOILS OF BEAR LAKE

The most common soil at 40,350 acres in Rich County is the Pancheri cool silt loam. This is followed by the Solak gravelly loam at 32,150 acres, the Duckree loams at 29,460 acres, and the Kearl loam at 28,100 acres (Soil Conservation Service, 1982). Generally speaking, the soils immediately surrounding Bear Lake are strongly alkaline, gravelly to cobbly sandy loams, rapid to moderately rapid permeability, with low to extremely low sediment loads.

The soils in Rich County are used mainly for agriculture. About 11,600 acres are used as non-irrigated cropland, 48,400 acres as irrigated cropland, hay land, and pasture land, and 594,720 as rangeland and forest land. Native and improved grasses grow well in the valleys and surrounding foothills and mountains providing feed for cattle and sheep, the most important segment of the economy of the county.

Soils of the Bear Lake Basin itself can be divided roughly into seven categories based on location, depth, and size of particles (BLRC, 1979). The first general category is the deep soils of the upland flats west of Bear Lake. These soils are well drained and the textures range from silt loam to clay loam. These soils are used for non-irrigated cropland, range and wildlife habitat.

On the steep slopes east and south of the lake, the second category has soils that are gravelly, cobbly and shallow. These soils have a high content of rock fragments throughout and are best used for wildlife habitat.

The third category, mostly covered by development along the shores and beaches, is dominantly sandy loam with varying amounts of gravel. These semi-desert area soils are well-drained alluvial deposits. The water table in this area is at or near the surface for significant periods of the year.

The wet meadows near Laketown, Sweetwater, and Round Valley areas make up the fourth category. These soils are poorly drained silty clay loams with gentle sloping surfaces. These soils are used for pasture and meadow hay cultivation.

**Bear Lake From Overlook Pass**

*Photo from: http://climchange.cr.usgs.gov/info/lacs/background.htm*

The deep, well-drained, silty clay soils of the top slopes comprise the fifth group. This area is around the edges of the valley west of the lake. These soils are mostly used for irrigated cropland.

The sixth category is the soils of the foothills south of Bear Lake. These soils are well drained clay loam and contain a wide variety of rocks. They support a vegetative cover of sagebrush, grass and other shrubs that are used dominantly for rangeland and wildlife.

The final category is the forested areas of the high mountains. They are characterized by deep well drained gravelly or very cobbly loam textures. These soils receive upwards of 30 inches of precipitation per year, mostly in the form of snow. Range, wildlife and timber are the major uses of these soils.

Part of the north, northwest, and northeast shores of the lake are sandy beaches. The remaining shoreline is rocky. However, this rocky zone is not extensive, extending only 12 feet into the lake. In general, the size of the particles decreases with increasing depth of the water. From the shore to a depth about 25 feet the bottom is sand, except for the rocky areas previously mentioned. This sand is gradually replaced by silt and marl. Below 80 feet the bottom material is a fine gray silt marl (Lamarra, 1979).

## MINERAL ACTIVITIES WITHIN RICH COUNTY, UTAH

The mineral resources of the area include deposits of phosphate, sand, gravel, limestone, quartzite, and oil. Large deposits of phosphate are in the northern and eastern parts of Rich County. U.S. Geological survey showed extensive deposits of rock-phosphate, stretching from the Crawford Mountains in Bear River Valley to Laketown and on through to Paris and Montpelier, and over the pass into Soda Springs (Parson, 1996). These deposits have been partially mined but continuing mining efforts remain highly dependent on the current market price.

The Arickaree Mine, located northeast of Randolph, was the first phosphate mine in Rich County. It began operation under the direction of Peter and Robert Bradley in 1906. The rock was shipped west to the American Agricultural Chemical Company in Los Angeles, California. The profits were insufficient and the mine was closed down a few years later. The San Francisco Chemical Company reopened the mine in 1954 but this too experienced economic setbacks and shut down in the 1960’s (Parson, 1996).

A second mine found in the Crawford Mountains, located 5 miles east of the town of Randolph, was mined extensively for phosphate from 1909 through 1972. To date 8.5 to 9 million tons of ore have been mined utilizing both underground and surface mining techniques to extract the ore. The Stauffer Chemical Company purchased both mines in the mid-1960's (Parson, 1996). Currently the landowners are listed as the Arickaree Development Company, Astaris, BLM, Crawford Mountain Properties, Inc., FMC Corporation, and Phosphate Industries, Inc. with Rich County holding the right-of-way to all sites. Early in 1998 the USDI Office of Surface Mining discovered a 7-mile long area left behind by underground mining to be in the process of collapsing. The Utah Abandoned Mine Reclamation Program began recovery of the area in 2000 and has restored the landscape to the pre-mining conditions (Amodt, 2003).

Continued mining activities in the area are unlikely due to active mining in the neighboring states of Idaho and Wyoming. Idaho production of phosphates constitutes over 12% of the national production. Currently there are 4 open-pit operations that produce almost 6 million tons of ore per year. It's industrial uses are largely for fertilizer and pure phosphate for phosphoric acid (Blanchard, 2002).

**Minnetonka Cave**

*Photo from: www.seidaho.org/images/bearlake/bloomington.jpg. Minnetonka Cave is the largest commercially developed limestone rock cave in the state of Idaho. The cave is located 10 miles west of Bear Lake.*

Environmental concerns have risen over the use of phosphate products and, along with developing open-pit mining technology; underground phosphate mining is currently at a stand still in Utah. Permian age phosphates mined on these sites have been the most important mineral commodity to date but these deposits are also a potential by-product source of fluorine, uranium, vanadium, selenium, chromium, nickel, zinc and molybdenum (Kaliser, 1972). No developed plans are currently in place to extract these minerals.

Limestone and quartzite are carbonate rocks with wide applications in industry and engineering. They occur in relative abundance in Rich County, Utah and Bear Lake County, Idaho areas. During the early part of the twentieth century, the citizens of Laketown constructed several stone buildings quarried out of the hills above the eastern shore of Bear Lake (Parson, 1996). There is no published evidence that stones from the area has been extracted since that time.

Future oil and gas production from Jurassic and older sandstone and limestone may surpass phosphate as the most important mineral commodity in the county (Soil Conservation Survey, 1982). The drilling has been exploratory up to this point. The first test well was drilled in Rich County fourteen miles east of Laketown in the late 1970’s and continued along the overthrust belt north. The most significant early well tapped was found 12 miles north of Randolph on Hogback Ridge (Parson, 1996). American Quasar Petroleum Company drilled the well which flowed an estimated 22.4 million cubic feet of natural gas. In 1980 Mountain Fuel Supply Company began construction of a pipeline from Hogback Ridge past Randolph and Woodruff to connect with the main supply line near Coalville, Utah (Parson, 1996). Rich County has seen cycles of petroleum exploration for the past 50 years. Early efforts tested anticlines identified from surface mapping and seismic reflection data. During the late 1970’s to early 1980’s companies drilled thrust belt-style structures in northern Utah. Although these efforts failed, “companies confirmed the area was similar in structural style, reservoir types, and timing to the productive thrust belts” found in other areas (Blanchard, 2002). The increasing demand for oil could rekindle thoughts of exploration in the Bear Lake area. See figure 7 for detailed map of the oil field.

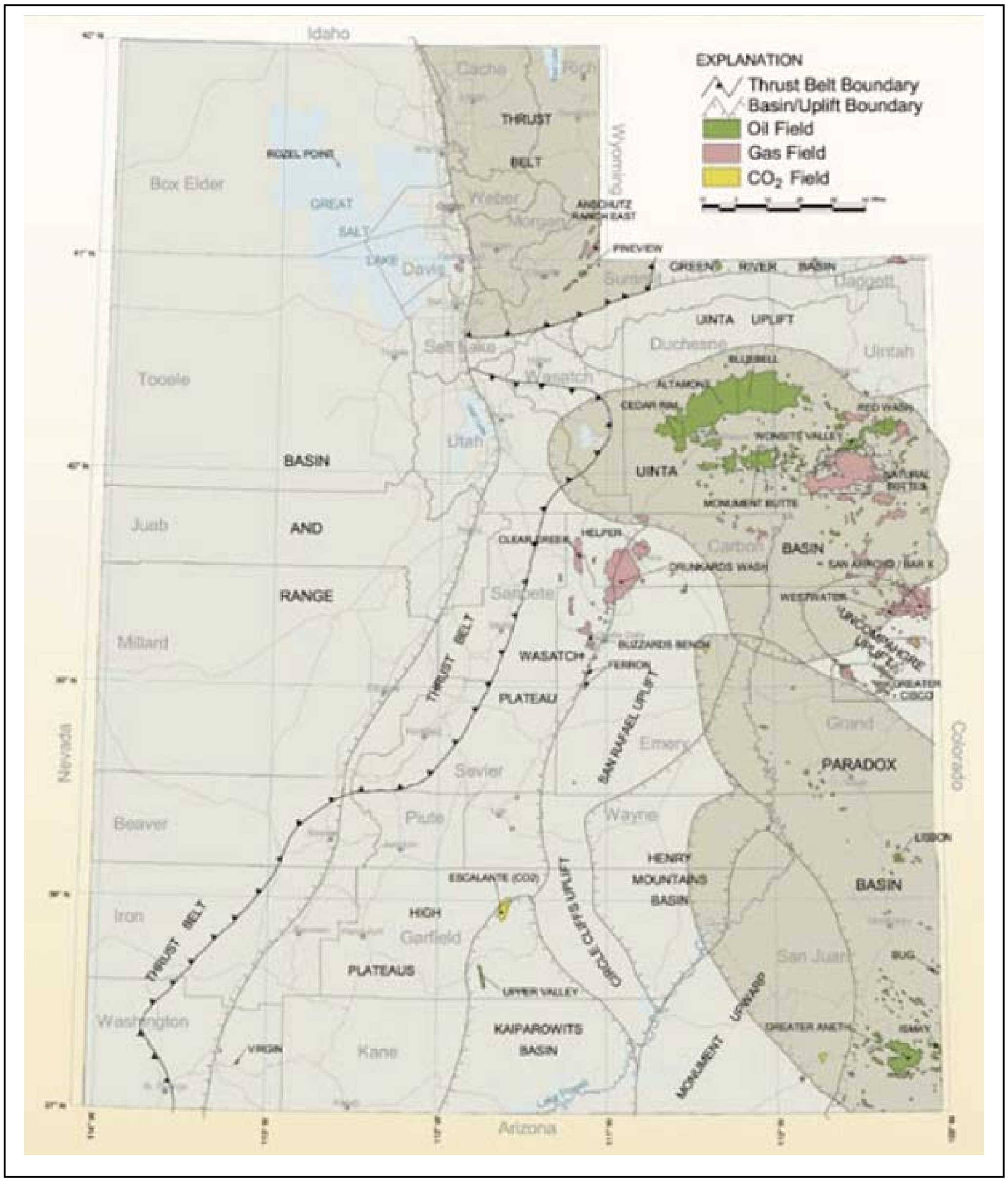


*Figure 7. Oil and Gas Fields in Utah Showing Geologic Provinces, Sedimentary Basins, and Principal structural boundaries (modified from Chidsey et al., 2005).*

# HAZARDS

The Bear Lake basin developed from fault subsidence that continues today, slowly deepening the lake along the eastern side. The Bear Lake graben is about 5 miles long and 4.3-8.6 miles wide. It extends across the Utah-Idaho border and involves faults on both eastern and western sides of Bear Lake. The faults around the lake are still active, but large magnitude earthquakes are relatively infrequent. Three quakes of magnitude 7+ on the eastern fault and 2 on the western fault have shifted the valley floor by as much as 18.4 ft in the last 6500 years (USGS, 2001). The most recent earthquake of that size was about 2000 years ago.

A severe earthquake along the Bear Lake fault would almost certainly trigger landslides in the area. Most of the resulting slides and slumps would occur in unconsolidated material along the east shore of the lake. Additionally, long periods of shaking caused during earthquake episodes create ground cracking and movement along the established fault lines. This is likely to occur across the delta fans in Round Valley and the Laketown area (Kaliser, 1972). Figure 8 displays the active fault lines in the basin.

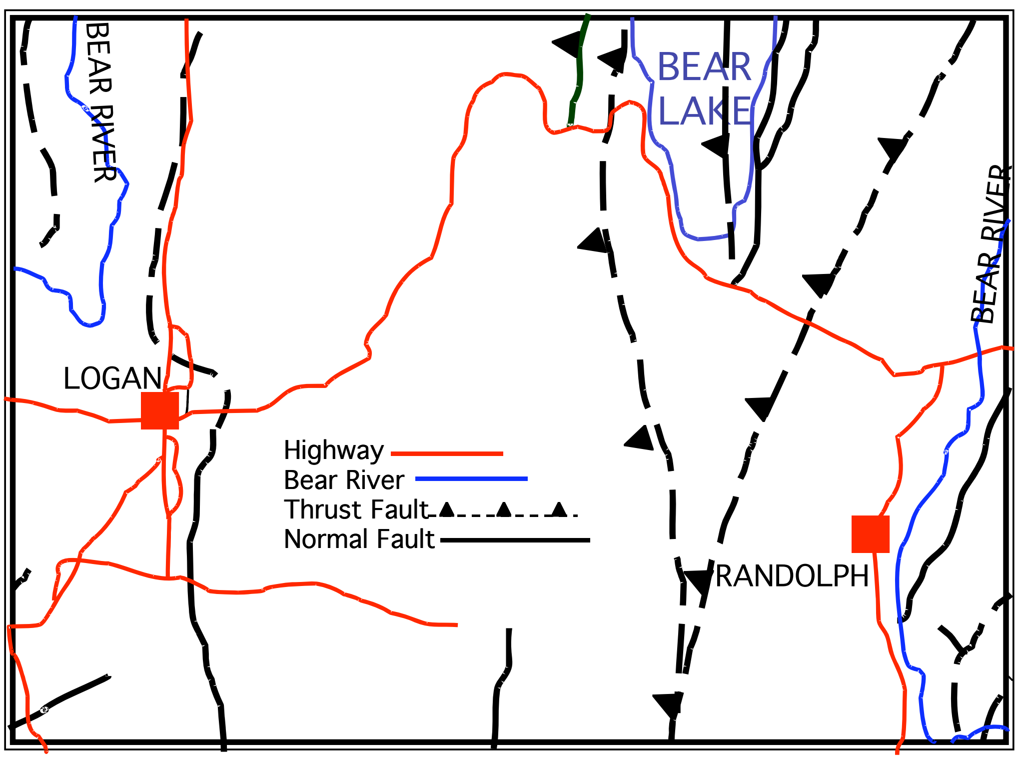



*Figure 8. Active Fault Lines in Rich County and the Bear Lake Basin (USGS Earthquake Hazard program, http://earthquake.usgs.gov, 2006).*

Both consolidated and unconsolidated materials are frequently subject to failure and slippage on slopes. Clear evidence indicates that slides occurred in the past in the Bear Lake area and that today there is not complete stability.  Old slides around the periphery of the lake are responsible for damming the outlet of Bear River and for the rising of the Bear Lake level (Williams, 1962). The west side of the lake gives evidence to having slid in several places leaving area of exposed fracturing. The bedrock formations in the area are either inherently weak or have been weakened through subsequent earth movements and pressures. The same is true on the talus slops common on the east shore of the lake. Series of cobbles and boulders at the road's edge along with dead trees on the slope indicate the activity of rock movement (Kaliser, 1972). Seiche waves generated by landslides or an earthquake in the North and South Eden deltas could potentially submerge, with destructive force, the opposite slopes (Kaliser, 1972).

Waterspouts observed over Bear Lake in 1996 and 1998 were accompanied by wind gusts of up to 80 mph. The waterspouts lifted some of the lake water a short distance into the air, but caused no serious damage nor inflicted any injury. Small tornados touched down over open land around Bear Lake in 1954, 1965, and again in 2004. In each instance the tornado remained on the ground for only a short time with a path mostly over open fields. Small outbuildings and trailers were damaged in the 1954 and 1965 instances but no damage was reported in 2004 (http://www.wrh.noaa.gov).

***Water Funnels Over Bear Lake***

*Photo from: http://newweb.wrh.noaa.gov/slc/climate/tornado.php*

Flooding of Bear Lake itself is not an issue. PacifiCorp's regulation of water levels is stipulated to remain at or below flood stage. To accomplish this PacifiCorp has established a late winter lake target elevation of 5918 to assist in spring flood mitigation, leaving a buffer of 5.56 feet or 390,000 acre-feet for basin flood control each year. The Utah Comprehensive Emergency Management team (2000) has not identified any areas of large flood potential adjacent to Bear Lake that are not associated with the Bear River. Small streams feeding Bear Lake may experience flooding during years of high mountain precipitation or rapid snowmelt. Debris related flooding is possible along Swan Creek and Big Creek. Rock slides caused by severe thunderstorms or spontaneous spring snowmelt could impact access along the eastern side of the lake.

## CLIMATOLOGY

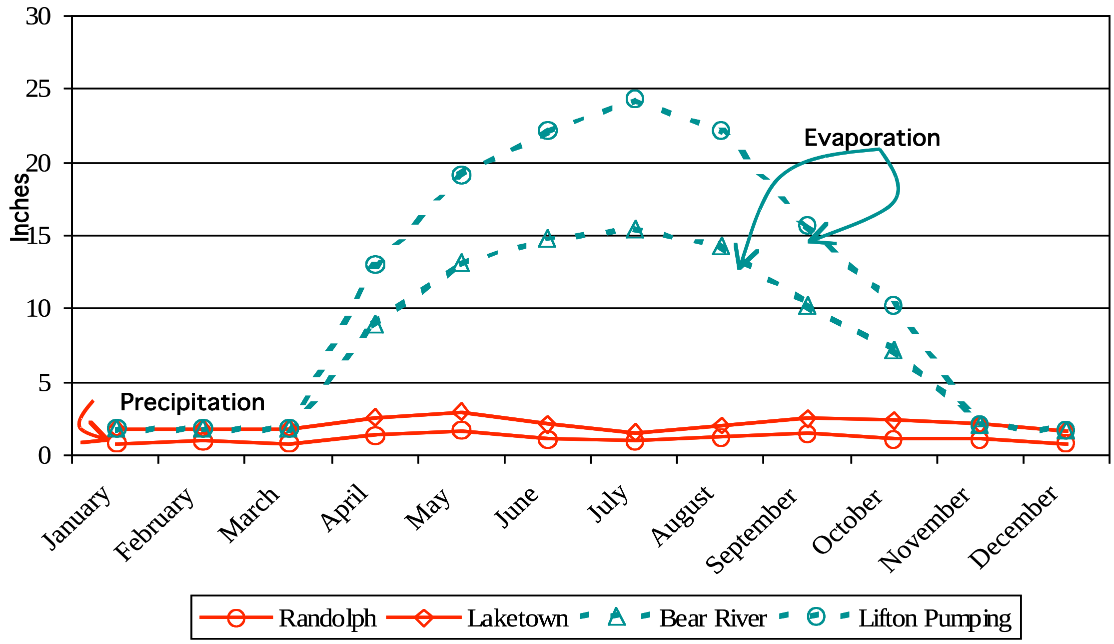
The climate in the valley is warm and dry during the summer, with the first snowfall coming during fall. Fog and snow are common during the winter. The lake is icebound during winter and most of spring. Generally the climatic conditions in Rich County are considered rather severe. Killing frosts are common until June and again in early September affecting a short growing season. It's high elevation makes this region one of the coldest areas in the state. The intense inversion also accounts for some extremely cold temperatures in winter. The coldest temperature on record, 50˚F below zero, was recorded at Woodruff in February of 1899. The warmest temperature at Woodruff was 96°F degrees in July of 1931. The maximum temperature recorded at Laketown was 98°F degrees in 1940.

The dominant precipitation in the area falls in the form of snow during the winter months. The seasonal accumulation is quite variable, ranging from only 40 inches on the lower valley bottoms to nearly 200 inches at the higher elevations. The normal annual precipitation ranges from a little less than 10 inches in the driest part of the county to nearly 50 inches at higher elevations. On average, Bear Lake receives a yearly total of 13.40 inches of precipitation. See table 6.

| Climatology of Bear Lake Valley | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Average Temperature (F°) | | | | Precipitation (in.) | | |
| | January | July | Mean Annual | Records | Avg. Snow Depth | Mean Annual | Frost Free Days |
| Randolph | | | 38 | | 34 | 11 | 50 |
| Maximum | 26 | 81 | | 92 | | | |
| Minimum | 0 | 43 | | -43 | | | |
| Woodruff | | | 39 | | 42 | 9 | 56 |
| Maximum | 29 | 82 | | 94 | | | |
| Minimum | 2 | 44 | | -47 | | | |
| Bear Lake, UT | | | 45 | | 41 | 14 | 109 |
| Maximum | 32 | 85 | | 92 | | | |
| Minimum | 12 | 50 | | -25 | | | |
| Laketown | | | 42 | | 43 | 12 | 85 |
| Maximum | 32 | 83 | | 96 | | | |
| Minimum | 11 | 48 | | -37 | | | |

*Table 6. Climatology of Rich County, Utah and the Bear Lake Utah/Idaho (Western Regional Climate Center, http://www.wrcc.dri.edu).*

As is normal for this part of the country, evaporation exceeds precipitation in the Bear Lake area during the summer. The Bear Lake Basin has several stations that have been recording climatological data for many years. Evaporation measurements at the Bear Lake / Laketown station show that the season of evaporation is from May to October. According to these measurements evaporation is from 4.9 inches in October to 13.9 inches in July.  Evaporation from the lake surface exceeds precipitation for most years. The Lifton pumping station just north of the lake shows similar rates with the low of 3.0 inches in October to a high of 8.73 inches in July. See graph 3 for average precipitation and evaporation in the Bear River Basin (Western Regional Climate Center, 2003).




*Graph 3. Average 25-Year Monthly Precipitation and Evaporation in the Bear River Basin 1975-2000. Red line indicates precipitation collected at Randolph and Laketown climate stations and the green lines represent pan evaporation from the Bear River, ID and the Lifton Pumping climate stations. (Western Regional Climate Center, 2003).*

## HYDROLOGY

Bear Lake's natural watershed is made up of relatively low mountains covered with sagebrush at lower elevations and southern exposures and fir-aspen forests at higher elevations and northern exposures. The basin is traversed by the Bear River that begins high in the Unita Mountains and flows through Utah, Idaho, and Wyoming before feeding the Great Salt Lake. The Bear River is the major river in the watershed but does not directly feed Bear Lake. The key inflow tributaries for the Lake are North and South Eden Creeks from the east, Fish Haven, St. Charles, Cheney, and Swan Creeks from the west, and Spring and Big Creek from the south. The outflow is a canal through Dingle Marsh and into the Bear River. Woodruff Narrows Reservoir is a major impoundment of the Bear River just downstream from Evanston, Wyoming, and there are small upstream impoundments on Birch Creek and both Eden Creeks (Judd, 1997).

Bear Lake is stratified in summer-spring where lighter water overlies denser water. During the winter months the mixing processes of winds and surface cooling break down the layers and the lake freezes over. Bear Lake does not completely freeze over every year but typically three out of five years. In it's stratified state; Bear Lake forms a distinct thermocline with an upper layer of warmer water with temperatures ranging between 58-72˚F and a lower layer of colder water between 35-42˚F. The temperature usually drops over just a few feet at a depth of 45-55 feet from the surface.

| Bear Lake Water Column Profiles | | | |
|---|---|---|---|
| Depth (feet) | Temperature (˚ F) | pH | Dissolved $O^2$ (ppm) |
| 16 | 59.9 | 8.8 | 7.8 |
| 49 | 59.5 | 8.8 | 7.9 |
| 82 | 46.8 | 8.6 | 8.1 |
| 115 | 41.5 | 8.5 | 7.1 |
| 148 | 41.0 | 8.3 | 6.2 |
| 180 | 40.8 | 8.3 | 5.4 |

*Table 7. Bear Lake Water Column Profiles (Judd, 1997).*

Table 7 details the average annual temperature, pH, and dissolved oxygen levels as they are in the water column of the Lake. The amount of dissolved oxygen present in the Bear Lake water column declines during the summer months as water temperatures rise. The late summer temperature and dissolved oxygen profiles represent the lake's most stressed period (Judd, 1997). More than 5 parts oxygen per million parts water is considered healthy; below 3 parts oxygen per million is generally stressful to aquatic organisms. Adequate dissolved oxygen is critical to most aquatic organisms and is one of the more important indicators of environmental health. Conductivity is a measure of the water's ability to carry an electrical current. The measurement is used in fresh water analyses to obtain a rapid estimate of dissolved solids or salts content of a water sample, a pristine mountain stream may have a conductivity range from 15-35 μmhos/cm whereas normal seawater will range between 50,000-60,000 μmhos/cm. Bear Lake generally carries a conductivity measure between 684-690 μmhos/cm (Judd, 1997). This reading has remained stable or only slightly increased since early investigations in the 1940's (Hassler,1960).

The pH is a measure of the activity of hydrogen ions (H+) in the water and is the measure used to determine its acidity or alkalinity. The pH levels in Bear Lake have remained at a consistent average of 8.0 (slightly alkaline) since Hazzard investigated them in 1934 (Sigler, 1972). This is a direct result of the high amounts of limestone and dolostone found in the area. The Bear Lake fault, under the eastern side of the lake, acts as a conduit for groundwater with numerous springs coming to the surface either on land or in the lake itself. These rocks weather by dissolution, producing many sinkholes, caves and springs. As a result, much of the water in streams entering Bear Lake originates as springs in the Bear River Range. (Kaliser, 1972).

***Bear Lake Over Garden City***

*Photo from: http://community.webshots.com/user/twinaterau*

*Bear Lake is often called the Caribbean of the Rockies for its intense turquoise-blue water. The unique color is due to the reflection of the limestone deposits suspended in the lake.*

Figure 9, modified from Lamarra (1979), shows the local watershed boundaries as they were defined in 1979.

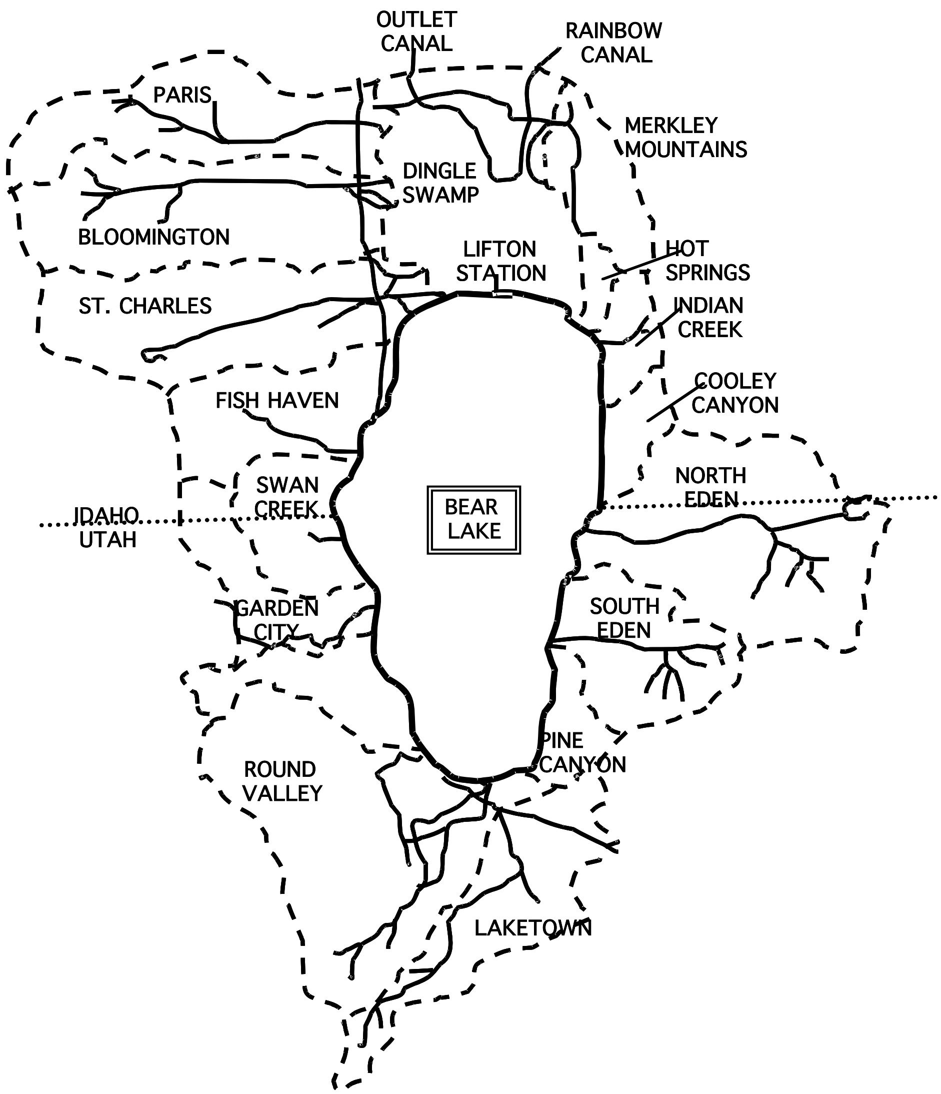



*Figure 9: Watershed Boundaries and Stream Locations (Modified from Lamarra, 1979).*

The 4 major and 3 minor tributaries to the lake, excluding the Bear River, drain a 228 square mile watershed. An average of 66,000 acre-feet of water per year enters the lake from this watershed. Historically, much of this water, over 55 inches on average, is evaporated during the summer months.

The lake and drainage characterizes are given in table 8.

| Lake and Drainage Characteristics | | | |
|---|---|---|---|
| | Surface Area | 112 miles square | |
| | Shoreline | 48 miles | |
| | Maximum Depth | 208 feet | |
| | Mean Depth | 94 feet | |
| | Lake Elevation | 5,924 feet | |
| | Volume | 6,550,871 acre-feet | |
| | Vertical Fluctuation | 10.5 feet | |
| **Primary Inflow** | | | |
| | Name | Drainage Area (square miles) | Mean Annual Flow (cubic feet / sec) |
| | Big Creek, Utah | 95.0 | 19.0 |
| | Indian Creek, ID | 4.5 | .21 |
| | North Eden Canyon, Utah | 53.0 | 11.0 |
| | South Eden, Utah | 23.0 | 4.8 |
| | Swan Creek, Utah | 4.0 | 18.0 |
| | Fish Haven Creek, Idaho | 12.0 | 3.4 |
| | Little Creek, Idaho | 36.0 | 7.1 |
| | Bear River Water | 104.0 | 26.5 |
| | Totals | 332.0 | 90.0 |
| **Outlet Channel** | | | |
| | Outlet Channel (Bear River) | 398.0 | 89.0 |
| **Evaporation** | | | |
| | Annual Average | 55.15 inches / year or 5% or total mean volume | |

*Table 8. Lake and Drainage Characteristics (Lamarra, 1979).*

## *INFLOWS*

Endemic inflows are those that have not been spatially altered by human influence. In the Bear Lake drainage endemic flows consist of 4 perennial streams, 2 major seasonal streams, and numerous near shore springs and ephemeral inputs. The perennial streams, located primarily on the western shore, are Big Sprig Creek, Swan Creek, Fish Haven Creek and St. Charles Creek. The seasonal or snowmelt driven streams are located on the east shore and are North Eden and South Eden Creeks. During drought cycles and low precipitation years all streams, except Swan

Creek, dry up or are dewatered for irrigation purposes. Swan Creek is protected as a culinary water supply and, due to its relatively high flows and short length, is rarely dewatered.

The first week of June typically has the highest rates of runoff. Stream flows on the Bear Lake tributaries in 2004, one of the driest years in this watershed, during the spring runoff period were:

Swan Creek 73.0 cubic feet/second

St Charles Creek 39.9 cubic feet/second

Big Spring Creek 17.2 cubic feet/second

Fish Haven Creek 13.5 cubic feet/second

The total tributary input was 164 cubic feet/second. During this year Bear Lake's elevation rose 1.5 feet during spring runoff (USGS, 2006).

In comparison 1997 was a wetter year and stream flow during peak runoff were:

Swan Creek 267.0 cubic feet/second

St Charles Creek 179.0 cubic feet/second

Big Spring Creek 98.2 cubic feet/second

Fish Haven Creek 77.3 cubic feet/second

Total tributary input was 638 cubic feet/second and that year the lake rose 7.5 feet during spring runoff.

The inflow estimates for 1983 are closer to the average for the Bear Lake watershed. In that year the peak runoff per stream were:

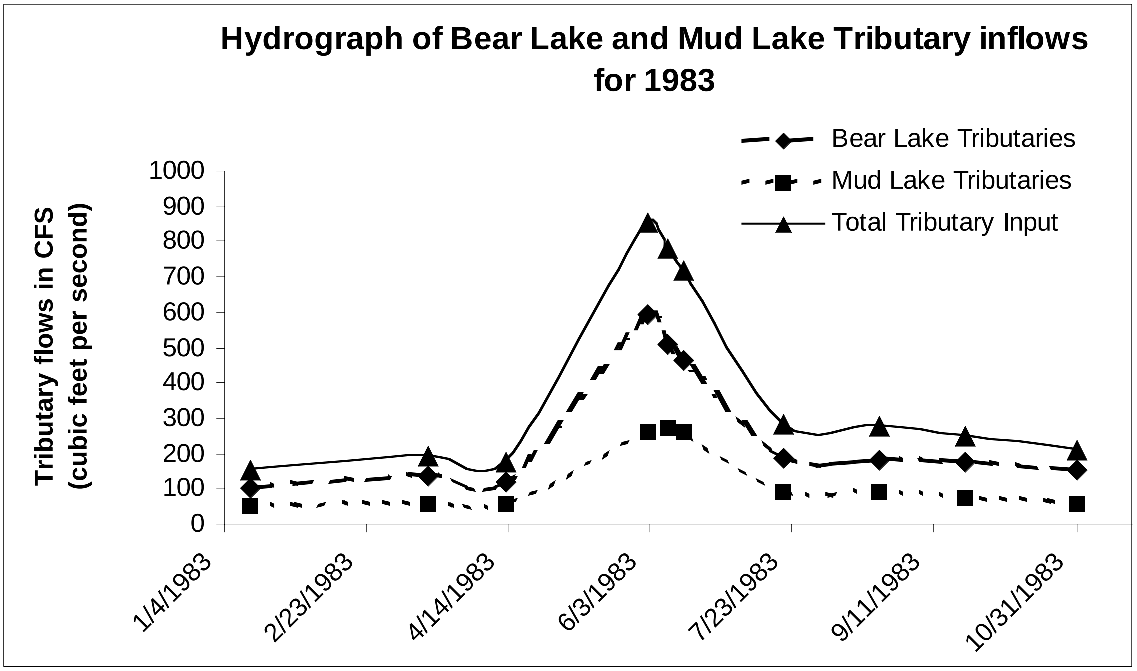
Swan Creek 249.0 cubic feet/second

St. Charles Creek 129.3 cubic feet/second

Big Spring Creek 93.9 cubic feet/second

Fish Haven Creek 82.9 cubic feet/second

Total tributary input for this typical year was 583 cubic feet/second and the lake rose 4.5 feet between April and July (Lamarra, 1986).




*Graph 4. Hydrograph of Inflows for 1983 (Recreated from Lamarra, 1986).*

Water flowing in Bear River is diverted to Bear Lake for storage. The point of diversion is located approximately 5 miles south of Montpelier, Idaho, at Stewart Dam. At Stewart Dam, most of the flow is diverted south into a canal and has an average annual flow of 26.5 cubic feet per second. Water is returned to the river below the Bear Lake outlet with an annual average of 776.9 cubic feet per second due to inputs from other tributaries. Graph 4 depicts the flows for the inflow tributaries of Bear Lake and Mud Lake from January to November of 1983. Flows are measured at two permanent gaging stations, one near Pescadero, Idaho below the Bear Lake outlet and the other above Alexander Reservoir, Idaho.

## *LAKE SEDIMENT CHARACTERISTICS*

Sediments deposited in Bear Lake region are largely composed of calcium carbonate, calcium, or limestone. These glacial sediments have a dominance of shale and sandstone that were formed by the compaction of the quartz-rich mineral grains that surround the lake. The lake bottom consists primarily of marl, a granular material composed largely of calcium carbonate and limestone fragments that contain varying amounts of organic matter. Marl sediment deposits are largely decayed organic material and minerals characteristic of Bear River drainage geology. Organic matter accumulation is higher when nutrient levels are increased. Water from the Bear Lake watershed is naturally low in organically available nutrients usable for organic growth and out-of-basin nutrient inputs can often increase productivity within the Lake itself (Wurtsbaugh, 1998).

Changes in sedimentation rates and nutrient composition have been recognized since the diversion of Bear River water back into Bear Lake in the early 1900's. Smoak and Swarzenski (2004) analyzed shallow cores of Bear Lake sediment to identify changes in bulk sediment and nutrient content over time, specifically the last 100 years. Sediment accumulation and nutrient concentration has increased markedly in the last century. The mass accumulation rates for sediment between 1866 and 1919 were 18 mg/cm$^2$/year; during the period from 1991-1998 they were 90 mg/cm$^2$/year. Nutrient analysis indicated increases of nitrogen (6-8 fold), phosphorus (3-8 fold), inorganic carbon (4-8 fold), and organic carbon (5-8 fold) for the same period of time.

The Bear River water enters through a canal, first at Mud Lake and then Bear Lake. The Bear River carries a large sediment load as it progresses through easily eroded rock upstream of Bear Lake Valley. This sediment falls out rapidly when the speed of water in the diversion channel slows upon reaching the swamp. The interactions of the waters with the swamp allows for a significant amount of nutrients to be taken from the Bear River waters and consumed in the marsh before it reaches the lake (USGS, 2001).

The mixed lake and river water leaves Bear Lake with the activation of the Lifton Pumping Station. An earthen causeway separates Bear Lake from Mud Lake. PacifiCorp controls the flow and structures located in the causeway and on May 6, 1993, the structure washed out. Mud Lake was higher than Bear Lake and materials from the causeway and silt from the adjacent Mud Lake washed into Bear

Lake. PacifiCorp has since designed and constructed a new control structure. The failure of the causeway prompted the Ecosystems Research Institute of Logan to investigate the water quality impacts of the building of the new structure. Total suspended solids and turbidity data was collected for eleven consecutive weeks at three open water stations during 1997. Data collected during this investigation have indicated that 75% of the sediment was removed by the marsh prior to its entrance into Bear Lake (Lamarra, 1997).

## *WATER QUALITY*

The completion of the pumping station inevitably modified the lake's physical and chemical characteristics. The water quality discussed in this section is based on conditions as they have existed since the pumping station began operating in 1918.

The water flowing into Bear Lake from both its Utah and Idaho tributaries were in compliance with state mandates for designated uses during their last review. The United States Environmental Protection Agency lists the tributaries of Swan Creek, Laketown Creek, Big Spring Creek, North Eden and South Eden as monitored sites that are meeting water quality standards as designated by the state of Utah. Each of the above water bodies is listed with "good" water status, indicating that all designated uses are being meet (USEPA, 2002).

The tributaries designated uses, as defined by the State of Utah, are for recreational activities; agricultural uses, such as irrigation and stock watering; and for cold-water aquatic species. Swan Creek has an additional designation as a culinary water supply for recreational contact activities and for cold-water aquatic species (Division of Administrative Rules, 2006).

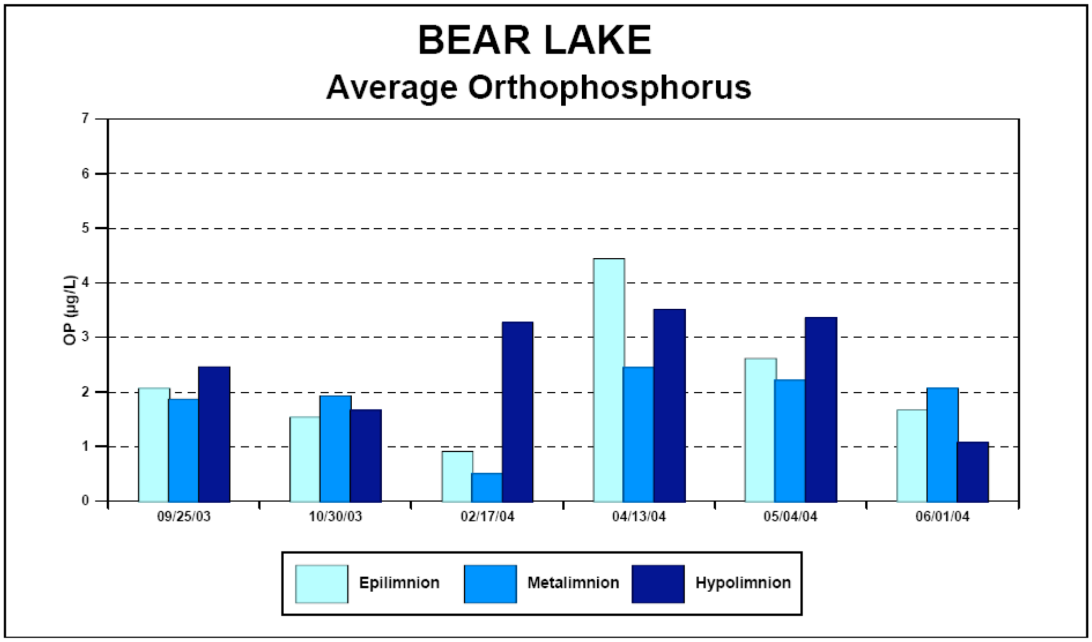
The waters within Bear Lake are also in compliance with the state of Utah beneficial use designation. Designations for these waters are for primary contact recreation, secondary recreation contact, coldwater fish and aquatic life, and for irrigation and stock watering (Division of Administrative Rules, 2006). Water chemistry according to the Judd (1997) and recognized by the Utah Division of Water Quality is outlined in table 9. The measurements are annual averages for the given years.

| Water Quality Data | | | | |
|---|---|---|---|---|
| Parameter | 1993 | | 1995 | |
| | Surface | Column | Surface | Column |
| Transparency (feet) | 15.4 | | 14.8 | |
| Total Phosphorus (ug/L) | 20.0 | 18.0 | 5.0 | 6.0 |
| Total Suspended Solids (mg/L) | 1.7 | | 2.0 | |
| Total Hardiness (mg/L) | | 289.0 | 294.0 | |
| Total Alkalinity (mg/L) | | 247.0 | 241.0 | |
| Ammonia (mg/L) | | .03 | | .03 |
| Nitrate/Nitrite (mg/L) | | .02 | | .01 |

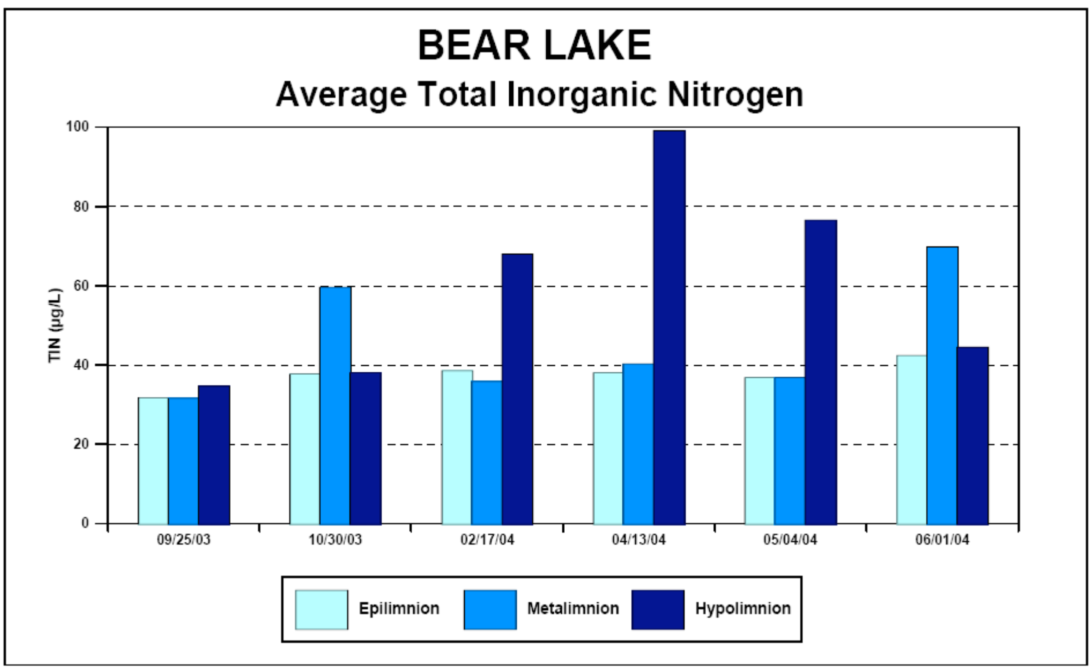
*Table 9. Water Quality Data for Bear Lake in Years 1993 and 1995 as Determined in Utah's Lakes and Reservoirs Classification and Inventory (Judd, 1997).*

The Clean Lakes Program, established in 1972 as section 314 of the Federal Water Pollution Control Act, sampled Bear Lake in 1982 to set a baseline assessment for future inventory and classification. Monitoring stations are available at the North Beach Idaho State Park and by Garden City for ongoing data sampling. These original studies determined that phosphorus, potassium, and nitrogen, although sparse in the shallow water, are adequate enough in the deep-water to support varied plant growth.

Specific studies designed to determine which nutrient limits growth of algae indicated that phosphorus and/or nitrogen almost always were the limiting factors. Sigler (1972) found nitrogen to be limiting more than half the time, whereas Birdsey Jr. (1989) suggests that phosphorus limited algal growth more often. In 2004, however, the Ecosystems Research Institute conducted a water chemistry analysis that showed relatively low levels of nitrogen and phosphorous throughout the year Graphs 5 and 6 on the following page illustrate this trend.




*Graph 5. Phosphorus Concentrations for Bear Lake 2003-2004. Epilimnion= shallow water, metalimnion=mid water and hypolimnion= deep water. Orthophosphorus is phosphorus that is usable by biological organisms (Ecosystem Research Institute, 2004).*




*Graph 6. Nitrogen Concentrations for Bear Lake 2003-2004. Epilimnion= shallow water, metalimnion=mid water and hypolimnion= deep water (Ecosystem Research Institute, 2004).*

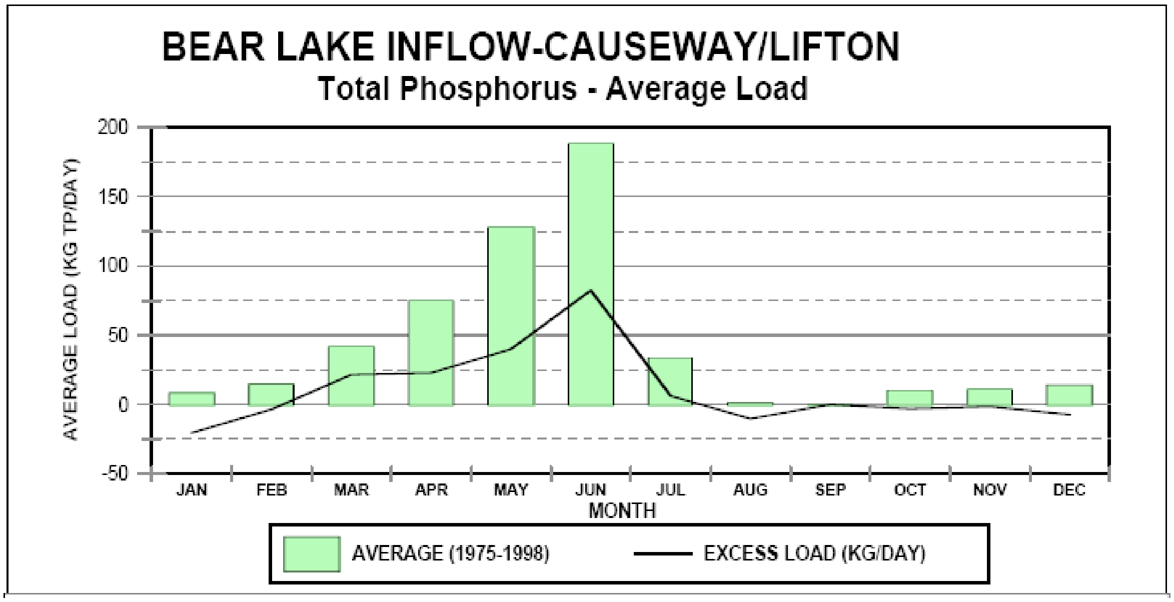
Nitrogen to phosphorus ratios indicated that the lake is likely to be phosphorous limited. The Ecosystem Research Center further determined there is significant nutrient loading by Bear River water as it enters the Lake through the Marsh. Smoak and Swarzenki (2004) claim that despite increased nutrient loading since the diversion of Bear River waters, chemistry does not appear to have changed significantly likely due to binding of nutrients to calcium in the water column and subsequent precipitation to and storage in sediment. The amount of biologically available nutrients is not associated with increased input of total nutrients.

The Ecosystems Research Institute (2005) produced a data summary, a report listing the Total Mass Daily Load (TMDL), and a report of the water quality for the Bear River drainage in Idaho. An excerpt from that report describes the conditions of concern for Bear River waters as they enter into Bear Lake proper:

> “the outflowing water quality at the Causeway station exceeds the TMDL criteria for total phosphorus in two of the four hydrologic periods. Because these periods occur during the filling cycle for the lake, these exceedances represent a significant source of phosphorus to Bear Lake. The largest exceedance occurs during upper basin runoff (51 kg TP/day) followed by lower basin runoff (22 kg TP/day). In the summer and winter base flow periods, no excess phosphorus enters Bear Lake. The total suspended solids mass does not exceed the TMDL limits established at the Causeway station.”

The Bear River itself, as it enters the upper basin from Wyoming, is currently classified for recreational and wildlife uses and under this classification the river meets standards. For the parameters of total dissolved solids, turbidity, hardness, iron and manganese, the quality of the Bear River in Utah exceeds drinking water supply standards (Division of Water Resources, 2000).

Graph 7 and Table 10 express visually the levels of phosphorus loading in the marsh during inflow and outflow from the lake. Excess loadings are based upon a criterion of 0.05 mg TP/l and 60 mg TSS/l during runoff season and 35 mg TSS/l during base flows. A total of 276 data points are represented in these figures.




*Graph 7. Distribution of Total Phosphorus Loads by Month and Excess Total Phosphorus for all Inflows into Bear Lake (Ecosystems Research Institute, 2005).*

Non-point pollution sources include the following: grazing, urban runoff, agricultural runoff, and feedlots. Natural inflows to the reservoir have deteriorated since the valley has been used for intensive agriculture. In addition, winter feedlots for livestock have destroyed streams that once were spawning grounds for cutthroat trout. The valley floor is composed of lake deposits in the form of layers of permeable sand and impermeable clay, which drain agricultural runoff directly into the lake rather than allow them to disperse. There are no discharging point sources of pollution in the immediate watershed. However, there are point source discharges into the Bear River prior to its diversion into the lake. One major discharger is the Evanston Wastewater Treatment Plant in Evanston, Wyoming (Judd, 1997).

| Month | Average Concentration mg/L) | Average Mass (kg/day) | Excess Mass over Criteria (kg/day) |
|---|---|---|---|
| **Total Phosphorus** | | | |
| January | 0.015 | 8.16 | -20.60 |
| February | 0.061 | 14.70 | -3.51 |
| March | 0.073 | 41.70 | 21.50 |
| April | 0.061 | 74.90 | 22.90 |
| May | 0.067 | 128.00 | 39.90 |
| June | 0.072 | 188.00 | 82.40 |
| July | 0.044 | 33.70 | 6.12 |
| August | 0.029 | 1.15 | -10.30 |
| September | 0.051 | 0.001 | 0.00 |
| October | 0.043 | 10.40 | -3.04 |
| November | 0.040 | 10.80 | -1.57 |
| December | 0.038 | 14.10 | -7.30 |
| **Total Suspended Solids** | | | |
| January | 7.74 | 7,880 | -9,470 |
| February | 6.31 | 1,230 | -11,300 |
| March | 30.90 | 16,000 | -6,110 |
| April | 21.40 | 31,400 | -19,000 |
| May | 30.40 | 75,700 | -31,700 |
| June | 23.00 | 64,700 | -52,900 |
| July | 16.70 | 12,500 | -17,400 |
| August | 16.30 | 0.363 | 0 |
| September | 12.40 | 0.3 | 0 |
| October | 12.10 | 6,690 | -5,260 |
| November | 26.10 | 5,910 | -2,740 |
| December | 19.00 | 13,000 | -1,920 |

*Table 10. Average (1975-1998) Water Quality Data for Selected Parameters at the Bear Lake Causeway and Lifton Pumping Station. Negative values under heading “Excess mass over Criteria” indicates kg/day lower than threshold criteria (Ecosystem Research Institute, 2005).*

## BIOLOGICAL RESOURCES

The Bear Lake basin has a range of land types that provide habitat for aquatic, riparian, and terrestrial wildlife and plant species. Near the lake a limited ring of semi aquatic plants grow in association with spring and creek waters. Agriculture lands are used as pasture and to grow feed crops such as hay and alfalfa. Larger stream inflows host riparian and aquatic meadow plants. The low hills of the valley support sagebrush, grasslands, pinion, juniper, maple, and brushy communities. In the higher mountains brushes give way to large tree complexes of aspen, spruce, pine, and their associated undergrowths. The very tops of the mountains contain alpine growth and parkland.

The Bear Lake National Wildlife Refuge at the north end of Bear Lake provides the largest area of wetlands, with nearly 30 square miles of open water and grassland habitat. This protected area provides nesting sites and migratory pathways for many shorebirds, wading birds, and waterfowl. Bear Lake itself is home to 4

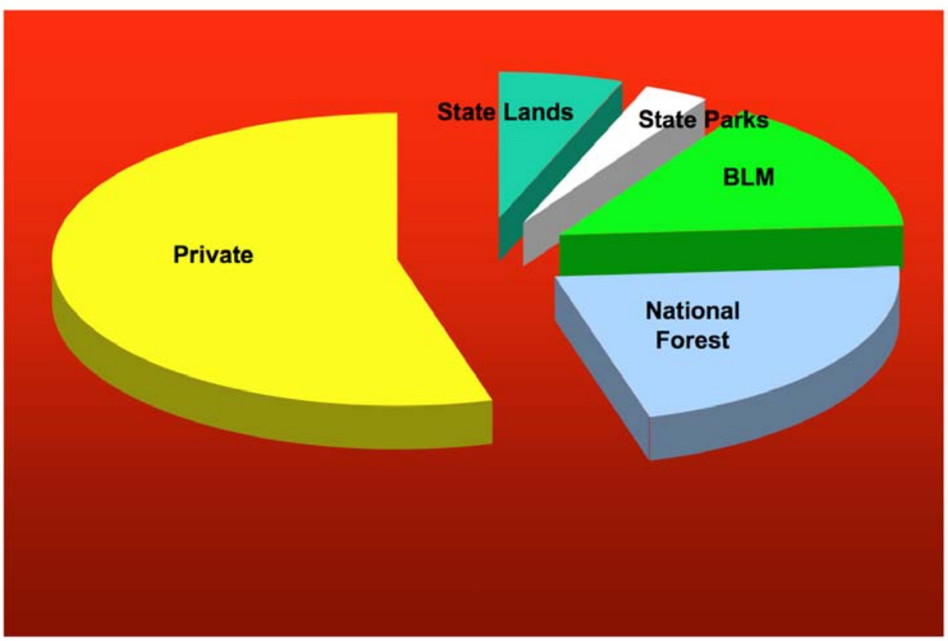



*Figure 10. Land Use Management within Bear Lake Basin in FY 2003/2004 Expressed as Percent. (Environmental Management Group, 2004).*

species of fish that are found nowhere else in the world: the Bonneville cisco, Bonneville whitefish, Bear Lake whitefish, and Bear Lake sculpin. Bear Lake also supports a strain of the Bonneville cutthroat trout that evolved in Bear Lake.

Stream corridors and bottomlands around Bear Lake are largely privately owned and are used for pasture and hay crop growth. Much of the steeper land surrounding the lake is managed by governmental agencies. Figure 10 present proportions for each organization. The Bear River Basin comprises 7,500 square miles including 2,700 in Idaho, 3,300 in Utah and 1,500 in Wyoming. The Bear River crosses state boundaries 5 times and is the largest stream in the western hemisphere that does not empty into the ocean. It is unique in that it is entirely enclosed by mountains, thus forming a huge basin with no external drainage outlets. Numerically the Bureau of Land Management administers 1,128 square miles or 15% of the basin, United States Forest Service operates 1,649 square miles or 22%. Idaho, Wyoming and Utah State Land Administrations has 424 square miles for 6% control, Idaho and Utah State Parks own 206 square miles for just under 3% of the basin, and 4,093 square miles (55%) are privately owned (Environmental Management Research Group, 2004).

## *VEGETATION*

The vegetation in the Bear Lake watershed is a mixture of sagebrush, rabbitbrush, bitterbrush, arrowleaf balsamroot, and associated grasses and forbs. Mountain mahogany and Utah juniper occurs in scattered clumps around Swan Creek and Meadowville. Other important browse include a combination of mules ear, snowberry, prickly pear, and serviceberry. Perennial grasses are represented by moderate amounts of bluebunch wheatgrass, sandberg bluegrass, and Indian ricegrass, followed by lesser amounts of bottlebrush squirrel tail. The most numerous perennial forbs are Utah milkvetch, thistle, wayside gromwell, and yellow salsify. Vegetation trend studies conducted for big game winter browse by the Utah Division of Wildlife Resources have been in place since the early 1980,s. Domestic sheep and cattle heavily grazed the eastern side of the lake at that time and many sites were declining due to high erosion, heavy use, poor vigor and drought. Study sites were placed within the Rich county portion of the Cache management unit and include Lower Hodges Canyon, Garden City Canyon, Meadowville, Swan Creek, Laketown Canyon, and North Eden. Key browse species include sagebrush, bitterbrush, mahogany and rabbitbrush. Management practices and favorable climate quickly improved the region. The 2001 trend study found a slight decline in key species density due to maturing plants at recent drought like conditions. Reproduction has been inadequate, it is reported, since 1990 due to poor numbers of seedlings and young plants. This trend is repeated on all sites. Historically, the amount of cheatgrass was up to 66% in Garden City, 63% in Lower Hodges, 60% in Swan Creek, and 34% in Laketown. This has declined over the years to approximately 10% in most locations to a low of 7% in Meadowville (Utah Division of Wildlife Resources, 2004). In the agricultural area, vegetation consists chiefly of the planted winter wheat with some invading forbs (Utah Division of Water Resources, 2000). Table 11 shows the percentage of each vegetation type.

| **Vegetation Type for Bear Lake Valley** | | |
|---|---|---|
| Land Cover Type | Percent of Total | Area in Square |
| Shrubland | 39% | 496 |
| Evergreen Forest | 12% | 155 |
| Herbaceous and Recreational | 10% | 124 |
| Pasture / Hay / Row Crops | 10% | 127 |
| Small Grains | 8% | 106 |
| Deciduous and Mixed Forest | 5% | 73 |
| Herbaceous and Woody Wetlands | 5% | 53 |
| Other | 11% | 133 |

*Table 11. Vegetative Land Cover of the Bear Lake Watershed (Bear River Watershed Information Systems at http://www.bearriverinfo.org)/.*

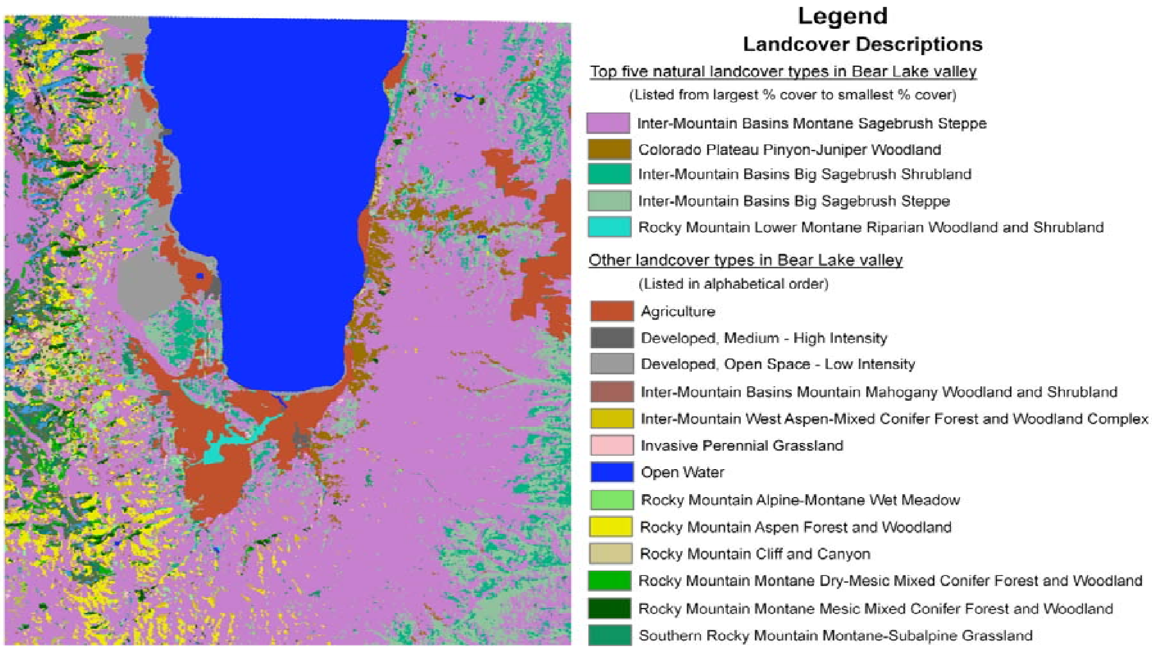



*Figure 10. Example of Land Cover Map as Illustrated in SWGAP Database.*

An extensive GIS project was conducted to map vegetative land covers of southwestern states (USGS, 2004). The example above is from the extensive database of vegetative types as digitized by the Southwestern Gap Analysis project. The SWGAP database can be found at http://earth.gis.usu.edu/swgap/.

## *PLANT SPECIES OF CONCERN*

The Utah Natural Heritage Program conducts on-going biological surveys of rare or declining species and plant communities. This database lists Rich County as having seven plants identified as regionally endemic but without range wide viability concerns. These plants will be monitored at the state level to detect declines in habitat, distribution or abundance. The seven plant species are: Wasatch rock-cress (*Arabis lasiocarps*), starveling milk-vetch (*Astragalus jejunus*), Garrett's milk-vetch (*Astragalus miser*), tufted cryptantha (*Cryptantha caespitosa*), Wasatch goldenbush (*Ericameria obovata*), Cache bladderpod (*Lequerella mutliceps*) and Cache owl's-clover (*Orthocarpus tolmiei*) (UDWR, 1998). The starveling milkvetch is also listed on the Wasatch-Cache National Forest and the Bureau of Land Management sensitive plant list for Rich County.

## *NOXIOUS WEEDS*

The state of Utah has designated 18 plant species as noxious weeds (Table 12). The Utah Noxious Weed Act defines "Noxious weed" as:

> "any plant the commissioner determines to be especially injurious to public health, crops, livestock, land, or other property" (Utah Division of Administrative Rules, 2006).

In addition to the state designation for noxious weeds, the Utah Noxious Weed Act requires each county to list weed candidates that are especially troublesome in that particular county. The list is then declared by the county legislative body to be a noxious weed within its county. Rich County designated the three following weeds as county noxious weeds in 2003 (Utah Department of Food and Agriculture, 2003): 1) Black Henbane (*Hyoscyamus niger); 2)* Dalmation toadflax (*Linaria dalmatica); and 3)* Poison Hemlock (*Conium maculatum).*

**State of Utah Noxious Weeds list. Bold indicates verified distributions within Rich County**

| Common Name | Scientific Name | Common Name | Scientific Name |
|---|---|---|---|
| Bermuda grass | *Cynodon dactylon* | Musk Thistle | *Carduus nutans* |
| Bindweed | *Convolvulus spp.* | Purple Loosestrife | *Lythrum salicarial* |
| Broad-leaved Peppergrass | *Lepidium latifolium* | Quackgrass | *Agropyron repens* |
| Canada Thistle | *Cirsioum arvense* | **Russian Knapweed** | ***Centaurea repens*** |
| Diffuse Knapweed | *Centaurea diffusa* | Scotch Thistle | *Onopordium acanthium* |
| **Dyers Woad** | ***Isatis tinctoria*** | Spotted Knapweed | *Centaurea maculosa* |
| Perennial Sorghum spp (Johnsongrass) | *Sorghum halepense, Sorghum Almum* | Squarrose Knapweed | *Centaurea squarrosa* |
| Leafy Spurge | *Euphorbia esula* | **Whitetop** | ***Cardaria spp*** |
| Medusahead | *Taeniatherum caput-medusa* | Yellow Starthistle | *Centaurea solstitalis* |

*Table 12. State of Utah Noxious Weeds List. Bold indicates verified distributions within Rich County (UDOT, 2005).*

Managing and controlling weeds in the Bear Lake Valley Cooperative Weed Management Area (CWMA) is a collaborative effort. Partnerships include: Utah and Idaho State Agencies, Rich County, UT and Bear Lake County, ID local governments, Utah State and Idaho State University Extension Services, specific interest organizations, and private parties. Highlands CWMA includes Rich County and portions of southern Idaho and western Wyoming. In 2004 the program treated 87 acres in the Bear Lake / Garden City area. The target species included dalmation toadflax, dyers woad, pepperweed, and yellow toadflax. Efforts included digging of plants, chemical spraying and the introduction of bio-agents (Highlands CWMA, 2004).

Other noxious weeds have been seen around Bear Lake or are expected in the very near future. Tamarisk is known to be growing around the shores of Bear Lake (J. Robinson personal observation). Species expected to soon be present in the Bear Lake valley include Leafy spurge *Euphorbia esula* (Rosenbaum, 2004) and Canada thistle *Cirsioum arvense*.

*Dyer's Wood (Isatis tinctoria ) Dyer's wood was introduced from Europe and thrives in waste areas, gravel pits, road sides, pastures, field edges, and disturbed soils. Infestations of dyer's wood increase more than 14% annually in the northern Utah. http://www.cwma.org*

**Dyer's Woad**
*Photo from: Noxious Weeds of Utah at http://utahreach.org/cache/govt/weedept/pg3_weedwisdom.html*

## *AQUATIC VEGETATION*

Aquatic plants increase total system production, provide food and cover for both invertebrates and fishes. Few vascular plants exist in the confines of Bear Lake. The most common is stonewort of the genus *Chara* which grows in beds of shallow water 15-30 feet deep (Scott Tolentino personal communication). Water milfoil in the genus *Myriophyllum* is often seen around the lake in areas with less than 3 feet of water (McConnell, 1957,). Vascular aquatic plants belonging to the genera *Utricularia* and *Potamogeton* have been found throughout the lake with limited distribution (McConnell, 1957).

*The level of production of aquatic plant material is one characteristic used to evaluate lakes. This is called the trophic state. Unproductive lakes are oligotrophic, while those water bodies that produce much organic material are called eutrophic. Intermediate productivity is called mesotrophic. The desirability of a particular tropic state is dependent upon the intended use of the lake. Oligotrophic lakes are valued for their high transparency, good swimming, and because they support fishes that require high oxygen levels. These lakes are managed to reduce nutrients levels. Eutrophic lakes managers increase nutrients to stimulate plant growth and fish production.*

Water level fluctuations diminish the possibility of in lake emergent plant survival. Emergent plants such as rushes, cattails, sedges, and grasses can be found where surface springs and streams enter the lake. Smaller rooted or poorly established plants are often removed by wave action when lake waters reclaim the spring zones.

When water levels are down vegetation such as willow, bulrush and common terrestrial weeds are often seen growing in dense patches along the silt and sandy beaches. Growth along the beaches is seen as “weedy” by both homeowners and recreationists. Section 404 of the Clean Water Act restricts mechanical actions that cause discharge of dredged material into the lake. The U.S. Army Corp of Engineers has provided guidelines for the removal of this woody material that would have less adverse impact on the aquatic ecosystem (USEPA, 2006). Phytoplanktons, microscopic photosynthetic plants that occupy the water column, are the dominant primary producers in Bear Lake. Members of the family of green algae are dominant with diatoms and blue-green algae sometimes present. The maximum abundance of species is in June-July coinciding with the highest temperatures.

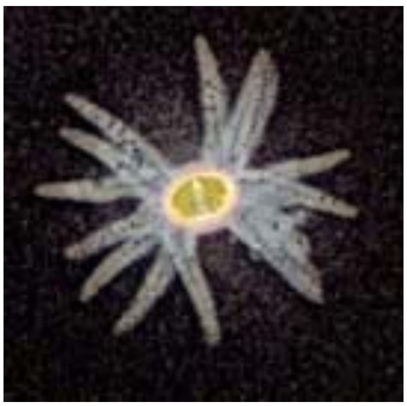
The input of nutrients, more specifically phosphorus, in a water body typically leads to an overabundance of phytoplankton, resulting in low transparency and reduced oxygen. In Bear Lake, however, excess phosphorus adheres to the abundant calcium carbonate in the water making it unavailable for the phytoplankton to use, leaving the lake with very low plant productivity (Environmental Management Research Group, 2006).

Moreno (1989), by measuring chlorophyll a concentrations, also concluded that Bear Lake has low plant productivity, with mean summer surface water chlorophyll a levels of only 0.5 ppm (Chlorophyll a concentrations below 0.95 ppm place the lake into the oligotrophic category). During lake water mixing events in spring and fall more nutrients are available and chlorophyll a levels increase to 1-1.5 ppm. During summer stratification in the deep cooler layer, chlorophyll a is often present and primary producers reach densities of 1.8 ppm (Wurtsbaugh and Hawkins, 1990).

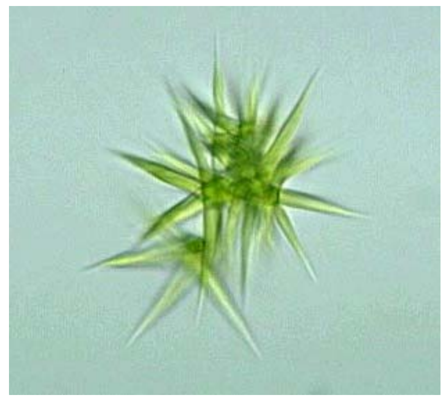
Wurtsbaugh (1998) analyzed existing research in order to infer the productive potential of the lake. His findings conclude that because of a nearly doubling of nutrients in the lake since the time of the diversions there is a consequent increase in plankton production. Despite the increased production, however, the lake has stabilized and is expected to remain in an oligotrophic state over time (Wurtsbaugh, 1998).

Numerous studies have been conducted in the Bear Lake that includes the sampling of phytoplankton to assess their abundance. Clark and Sigler, in 1961, sampled the lake during September, March, and July. The dominant species found in this study were: green algae, *Ankistrodesmus (52%) and Oocystis (23%),* blue-green algae *Lyngbya (22%)*, and *Diatoms (3%)*.

The Division of Water Quality, more than 30 years later, recognized four taxa as dominant in the Bear Lake. The species, all green algae, are *Ankistrodemus (64%), Lagerheimia (32%)*, and *Chlamydomonas* and *Oocystsis* (2% each) (Judd, 1997).



***Lagerheimia ciliata***



***Ankistrodemus falcatus***

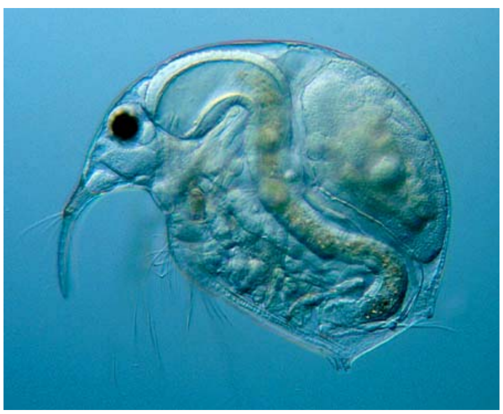
*Photos from: http://protist.i.hosei.ac.jp*

## *ZOOPLANKTON*

Zooplankton are any small animals with limited mobility that reside in the water column. Their distribution within Bear Lake are controlled by temperature and food availability. Larger zooplanktons are important food for forage fish species and larval stages of all fish. The majority of the zooplankton community in Bear Lake is composed of primary consumers, which eat phytoplankton. Copepods, however, become carnivorous and consume other zooplankton during the adult life phase.

Zooplankton, like phytoplankton, indicate the trophic conditions within the Lake. Looking at zooplankton biomass, abundance and species diversity can assess environmental quality and ecological change. Shifts in zooplankton communities can be correlated to eutrophication in freshwater lakes (Gannon, 1978).

Zooplankton samples have been collected in various studies and during several time periods. Early studies by Kemmerer (1923) and McConnell (1957) found the calanoid copepod, *Epischura,* to be the dominant zooplankton. Lentz (1986) described a community comprised primarily of *Epischura* and the rotifer, Conochilus. Lentz's findings concurred with earlier work by Nyquist (1967). Moreno (1989) documented the dominant species as *Epischura* and the cladoceran, *Bosmina*. Taxonomic identification, size, food source and abundance are given in Table 13.

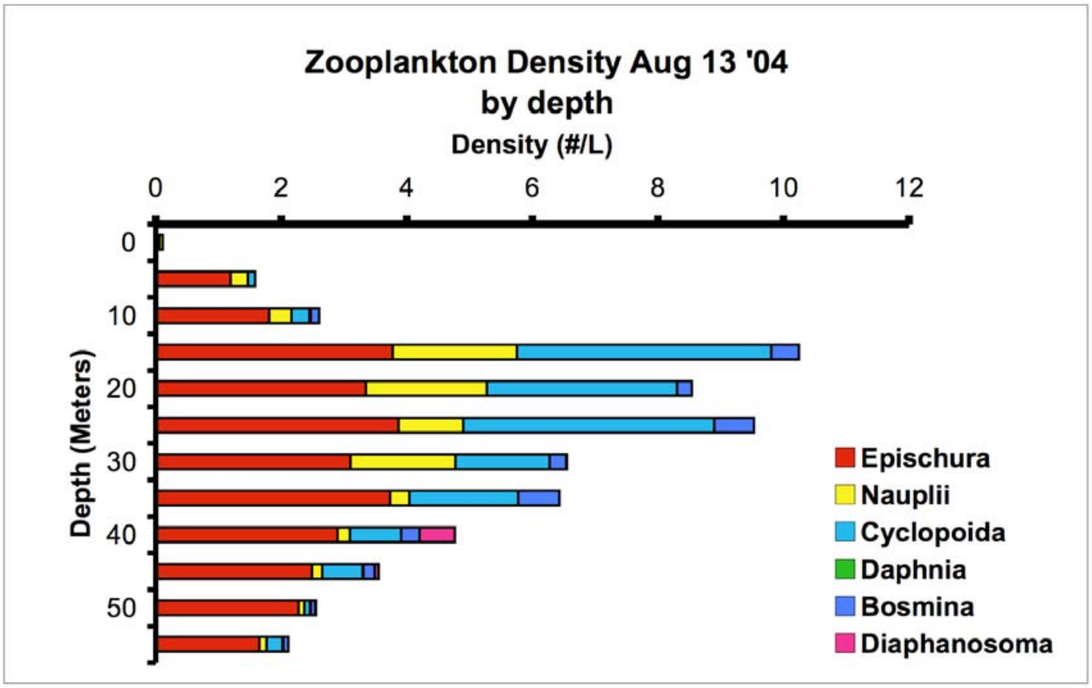


Currently the calanoid copepods still dominate zooplankton biomass, but 2 small cladocerans can be numerically dominant during summer. During the mid 1990s studies by Mazur and Beauchamp (2000) and Wurtsbaugh and Luecke (1998) found *Daphnia* in high numbers (~6.5/pint).


*Photos from: http://www.microscopy-uk.org.uk/*

Increased presence of Daphnia is hypothesized to be a result of increased nutrient content in the lake as water levels increased after an extended period of drought (see graph 1). Daphnids are one of the most efficient water column grazers and would likely be the most rapid responder to increased productivity.

Moreno (1989) found that there is little variation in zooplankton density as one moves laterally around the lake. Estimates of shallow water zooplankton density (number of individuals/liter of lake water) were not significantly different than those of deep water. Variation in zooplankton biomass (weight of individuals/volume of lake water) changes extensively with water depth (Wurtsbaugh and Luecke, 1993). Zooplankton densities are highest (Graph 8) near the thermocline in summer and were associated with high concentrations of phytoplankton. Chlorophyll concentrations were highest in the 35-50 foot depth interval where larger cladocers became more abundant. Many of the invertebrates seen in the water column are also found at water-sediment interfaces (Wurtsbaugh and Hawkins, 1990).




*Graph 8. Vertical Profile of Zooplankton Density for August 2004. Calanoids (Epischura, Cyclopoids and their juvenile life stages (nauplii)) dominated the assemblage. Samples were taken at 5-meter intervals from 0-55m. Water depth was 57m (Wurtsbaugh and Luecke, 1993).*

| *Genus and species* | Max Abundance | Length Range | Mean Length | Trophic Group |
|---|---|---|---|---|
| **Crustacea** | | | | |
| **Cladoceran** | | | | |
| Bosmina longirostis | 5,200 | 0.20-0.50 | 0.35 | Grazer |
| Daphnia pulex | 500 | 0.36-1.98 | 0.91 | Grazer |
| Ceriodaphnia reticulata | 2,500 | 0.20-0.99 | 0.58 | Grazer |
| Diaphnosoma brachyurum | 250 | 0.36-1.32 | 0.74 | Grazer |
| Chydorus sphaericus | 30 | 0.20-0.79 | 0.46 | Grazer |
| Alona costata | | | | |
| Alona afinis | 65 | 0.42-0.42 | 0.42 | Grazer |
| Aslona quadrangularis | | | | |
| **Copepoda** | | | | |
| Copepoda nauplii (all infant copepods) | 6,000 | 0.07-0.36 | 0.20 | Grazer/ Predator |
| **Calanoid** | | | | |
| Epischura nevadensis (Adult) | 1,150 | 0.99-1.48 | 1.12 | Grazer/ Predator |
| Epischura nevadensis (juvenile) | 2,400 | 0.30-0.99 | 0.64 | Grazer |
| **Cyclopoid** | | | | |
| Paracyclops fimbriatus | 120 | 0.46-0.85 | 0.64 | Grazer/ Predator |
| Eucyclops agilis | 130 | 0.50-1.00 | 0.62 | Grazer /Predator |
| Acanthocyclops vernalis | 60 | 0.82-1.20 | 0.84 | Grazer /Predator |
| Cyclpoida juveniles | 200 | 0.30-0.63 | 0.38 | Grazer |
| **Harpacticoida** | | | | |
| Canthocamptus robertcockeri | 15 | 0.53-0.59 | 0.53 | ? |
| Mesochra rapiens | 12 | 0.40-0.59 | 0.45 | ? |
| Huntemania lacustris | 35 | 0.46-0.59 | 0.49 | ? |
| **Rotifera** | | | | |
| Keratella quadrata | 106,000 | 0.10-0.17 | 0.13 | Grazer |
| Keratella cochlearis | 9,600 | 0.07-0.13 | 0.10 | Grazer |
| Branchionus sp. | 6,300 | 0.07-0.26 | 0.11 | Grazer |
| Conochilus unicornis | 2,000,000 | 0.07-0.10 | 0.10 | Grazer |
| Polyarthra sp. | 1,000 | 0.07-0.13 | 0.10 | Grazer |

*Table 13. Crustacea Found in the Water Column, With Associated Maximum Abundance, Max and Min Lengths and Trophic Group. Data represents samples collected October 1986-December 1987 (Recreated from Moreno, 1989).*

## *BENTHIC MACRO INVERTEBRATES*

Wurtsbaugh and Hawkins (1990) reported at least 70 taxa of invertebrates associated with the bottom of Bear Lake. The authors note that this is a conservative estimate of species richness due to the difficulty associated with identification to species levels. The numerical majority of the invertebrates were associated with 5 taxonomic groups: worms (nematodes or round worms and Annelids or segmented worms)(6+ species), mites (2+ species), crustacean (other than ostracods)(12 species), ostracods (5+ species) and chironomids (31+ species). Other taxa included representative species of Coelenterata (hydra), Insecta (Ephemeroptera, Plecoptera, Tricoptera, Odonata) and Diptera (Empididae) Table 14 on the following page lists the genus, species and family of samples collected in 1987.

Benthic invertebrate production was very low during 1987 (Wurtsbaugh and Hawkins, 1990) and whole-lake estimates of mean annual biomass were 0.34 grams dry weight per meter squared. Chironomids were the dominant organisms followed by worms and ostracods and then crustaceans. These comprised 40%, 20%, 20% and 15% of the benthic invertebrate biomass respectively. Benthic invertebrate biomass was highest in shallow waters and declined with increasing depth. Oligochoete worms dominated upper sections of the lake, mid-reaches held the most chironomids and deep water was associated with ostracods. Crustaceans were found throughout the benthic-water column interface with highest densities found near the deep chlorophyll layer in summer months. Mites made up little of the biomass of the lake and were only found in high numbers near rock and plant structures. Benthic invertebrates feed on algae, macrophytes, detritus and each other.

| Genus and Species | Family | Genus and Species |
|---|---|---|
| **Ceolenterata** | **Diptera** | |
| Hydra | Empididiae | |
| nematoda | Chironomidae | |
| **Annelida** | Tanyodinae | |
| Oligocheata | | Alabesmyia |
| Hirudinea | | Natarasia |
| **Crustacea** | | Psectrotanypus |
| Cladoceran | | Placladius |
| Alona costata | Diamesinae | |
| Alona afinis | | Potthastia |
| Alona quadrangularis | | Monodiamesa |
| Chydorus sphaericus | Orthocladiinae | |
| Copepoda | | Corynoneura |
| Huntemania lacustris | | Cricotopus |
| Mesochra rapiens | | Eukiefferiella |
| Cyclops vernalis | | Orthocladius |
| Eucyclops | | Paraphaenocladius |
| Paracyclops | | Psectocladius |
| Ostracoda | | Tretenia |
| Amphipoda | | Unknown |
| Gammerus lacustris | Chironominae | |
| **Arachnoidea** | | Chironomus |
| Hydrocaria | | Cladotanytarus |
| Hygrobates | | Cryptochironomus |
| Lebertia | | Cryptotendipes |
| **Insecta** | | Dicrotendipes |
| Ephemeroptera | | Microchironomus |
| Caenis | | Micropsectra |
| Batis | | Microtendipes |
| Drunella | | Nilothauma |
| Heptagenia | | Paracladopelma |
| Odanata | | Polypedilum |
| Plecoptera | | P. pentapedilum |
| Trichoptera | | P. tripodrus |
| Hydroptila | | Strictochironomous |
| Oecetis | | Unknown #1 |
| Polycentropus | | Unknown #2 |

*Table 14. Benthic Invertebrates Collected in Bear Lake from February to October 1987 (Recreated from Wurtsbaugh and Hawkins, 1990).*

# FISH

There are 13 species of fish found in the waters of Bear Lake. Of those 13, 4 are endemic (found only in Bear Lake). The 4 endemics species are Bonneville cisco, Bonneville whitefish, Bear Lake whitefish, and Bear Lake sculpin. Five of the remaining 9 fish species are native to the region, and 4 are exotic introductions. These native fishes are the Bonneville cutthroat trout, Utah sucker, redside shiner, speckled dace and Utah chub. The exotic fishes are lake trout, common carp, yellow perch and green sunfish.

Four other species of fish are found in tributaries of Bear Lake. These are exotic rainbow trout, exotic brook trout, native mountain whitefish, and native mottled sculpin. These fish have access to the lake at most times of the year, yet they are rarely documented in the lake by either researchers or fishermen. The majority of the fish in Bear Lake occupy benthic habitats, though almost all fish will enter the water column at various times. The one exception is the Bonneville cisco, which feeds in the open water pelagic region of the lakes and uses benthic habitats only during spawning.

**Fishermen 2005**

*Photo from www.larrystark.com/FishingBearLake.jpg*

## *ENDEMICS*

One half of the species present in the whitefish genera Prosopium reside only in Bear Lake. They are P. abyssicola (Bear Lake whitefish), P. gemmifer (Bonneville cisco) and P. spilonotus (Bonneville whitefish). Geographic isolation has facilitated niche partitioning within the genus. Both whitefish are benthically oriented, while the cisco feeds and resides in the pelagic zone (Kennedy, 2005).

These endemic whitefishes have distinct life histories and feeding habits. Bonneville cisco feed mainly on zooplankton with diets mainly consisting of the Calanoid copepod, Epischura, Cladocera, and also Daphnia when it is present in the water column. Age-0 cisco will reach lengths of 2 inches during their first summer and reach maturity as 3 year olds when total body lengths exceed 7 inches. Older adults can attain lengths of 12 inches. Cisco are fed on extensively by piscivorous trout. Stomach contents of larger cutthroat and lake trout often consist entirely of cisco. (Wurtsbaugh and Hawkins, 1990; Ruzycki et al., 2001). Cisco are generally present in waters of less than 60°F. During summer these temperatures are present below the thermocline at depths of 50-80 feet (Luecke and Wurtsbaugh, 1993).

**Bonneville Cisco** *(Propium gemmiferum), Photo from aslo.org/photopost/data/508/8BLT05_Bear_Lake*

Estimates of Bonneville cisco abundance for the lake ranged from 1.9 million cisco in 1991 (Mazur and Beauchamp 1999) to 9.7 million in 2001 (Scott Tolentino personal communication). These abundance estimates, developed using hydroacoustic methodology (Luecke and Wurtsbaugh 1993), indicated that cisco were most abundant in mid-water depths in the eastern and southern regions of the lake. High population variability is thought to be associated with the impact of water level fluctuations in the lake on cisco spawning success (Wurtsbaugh and Luecke, 1998).

Cisco spawn during the month of January in rocky-bottomed portions of the lake. Rock is often associated with the shallow margins of Bear Lake. Cisco spawning offers a unique angling experience; the fish are scooped out of the water through large holes in the ice by dip nets, when ice is not on the lake boats and waders allow access. Anglers consume some cisco but more use the fish as bait for trout.

The early life history of the Bonneville cisco is reasonably well-known (Bouwes 1995; Bouwes and Luecke 1997). Fertilized eggs deposited in January are subject to predation from a variety of egg predators. Bouwes and Luecke (1997) indicated that less than 5% of fertilized eggs survived to hatching. Age-0 cisco hatch from eggs deposited in early May. These larvae swim to the surface water and begin consuming small crustacean and ciliate zooplankton. Growth is rapid in the warmer, food-rich surface waters of the lake. Predation on eggs and larvae generally exceeds 99% of fertilized eggs and likely determines cohort success in this species (Bouwes, 1995).

Bear Lake and Bonneville whitefish are thought to have speciated from the more common Mountain whitefish (P. williamsoni) during the past 30,000 years (Kennedy, 2005). Mountain whitefish are found in the Bear River and some Bear Lake tributaries, but not in the lake itself. The spawning periods and depth distribution of these 2 closely related species are distinct and contribute to reproductive isolation (Albrecht, 2004; Kennedy, 2005). Spawning of Bonneville whitefish occurs in December on rocky shoreline areas and the Rock Pile near Gus Rich Point. Bear Lake whitefish spawn on the Pock Pile during February (Albrecht, 2004). No good estimate of Bonneville or Bear Lake whitefish has been made, but relative catch rates suggest that several million Bonneville and close to 1 million Bear Lake whitefish are present in the lake.

Bear Lake whitefish reside in the cold waters below the thermocline, where they feed primarily on ostracods (Thompson, 2003). The use of the less productive regions of the lake likely represents a trade off between slower growth in these deep waters, and lower predation risk. Kennedy (2005) indicated that predation rate on juvenile whitefish was 3 times greater in the mid-water depths (50-100 feet) compared to deeper depths (>130 feet). Reduced food quality and colder temperatures present at 130 feet deep (~40ºF year-round) lead to reduced growth rates and smaller lengths at maturity compared to Bonneville whitefish. Bear Lake whitefish have been ages to over 30 years with maximum lengths near 12 inches. They are rarely caught by fisherman and are not usually thought of as a gamefish.

Bonneville whitefish occupy the warmer and more productive mid and upper portions of the lake bottom and thus grow more rapidly and attain larger body lengths. Total body length can exceed 20 inches during their ~20-year life span (Thompson, 2003). Benefits of warmer temperatures and more food availability are offset by increased risk of predation from large trout. Bonneville whitefish demonstrate ontogenetic niche shifts when they reach lengths near 10 inches and become piscivorous (Mazur and Beauchamp, 1999) feeding on small fish of all species but especially sculpin. Fisherman occasionally capture these larger fish.

Bear Lake sculpin (Cottus extensus) are the only sculpin in the western United States that occupy deep water lake habitats. Bear Lake sculpin occupy the benthic regions of the lake where they feed on aquatic macro-invertebrates and zooplankton. They are small fish that rarely attain 4 inches in total body length. They are relatively long lived for a small fish with some aged at 8 years (Ruzycki and Wurtsbaugh, 1995). The population size of Bear Lake sculpin has been estimated at 1-2 million fish (Wurtsbaugh and Luecke, 1998).

Bear Lake sculpin reproduce in late spring with adults moving into shallow rocky areas. Males compete for nesting sites, which are comprised of the undersides of fist sized and larger rock. When males have established territories females circulate through the area looking for a suitable mate. Larger males tend to successfully defend their breeding site and thus have the most access to females. Females lay adhesive eggs on the roof of the nest, which the males then fertilize. After mating, the females leave the nest site and males care for the young. This parental care includes protection of fertilized eggs from egg predators and cleaning of eggs from fungus and bacteria (Ruzycki et al., 1998). During the 4-6 week incubation males fan the eggs with their pectoral fin to remove waste and provide oxygen, during this time they are not believed to leave the nest even to feed.

**Bear Lake Sculpin** *(Cottus extensus) Photo from aslo.org/photopost/data/508/8BLT05_Bear_Lake*

The fertilized eggs of Bear Lake sculpin hatch in late May and early June and larval sculpin move to the surface waters where water currents can disperse them around the lake. Soon after dispersal juvenile Bear Lake sculpin begin a diel pattern of vertical migration. These age-0 individuals leave the bottom of the lake at night and ascend up to 130 feet into the water column. This behavior allows these juvenile fishes to occupy warmer water and thereby increase growth rates (Neverman and Wurtsbaugh, 1994).

Bear Lake sculpin are an important food resource for cutthroat and lake trout. Greater than 70% of the diet of intermediate aged lake trout are composed of sculpin. The percent of sculpin in diets of older lake trout decline to 20% (Ruzycki and Wurtsbaugh, 1995). Intermediate ages of cutthroat, 10-14 inches in total length, used Bear Lake sculpin as their major prey source throughout winter and spring months (Wurtsbaugh and Hawkins, 1990). Wurtsbaugh and Luecke (1998) found that predators could consume a substantive portion of the annual Bear Lake sculpin production.

Fluctuating water levels likely affect sculpin populations. Spawning habitat is limited to the ring of rock habitats associated with high water elevations. When water levels are lowered there is increasingly less habitat available for Bear Lake sculpin spawning (Albrecht, 2004). Water levels in the spring of 2005 were down 24 ft. from full pool, these reductions reduced available spawning habitat to less that 5% of total potential (Albrecht, 2004). In low water years, high predation pressure and limited spawning habitat can reduce abundance of Bear Lake sculpin in the lake. A computer simulation model indicated that increased lake trout stocking posed a greater potential threat to Bear Lake sculpin than any other fish species in the lake during these periods of low water (Albrecht, 2004). The Utah Division of Wildlife Resources has reduced stocking of lake trout in response to concerns about prey fish abundance.

### *NON-ENDEMICS*

The Bear Lake strain of the Bonneville cutthroat trout (Onchorhyncus clarki) plays an important role as a population center for this species of conservation concern. Genetically pure lake strains of Bonneville cutthroat are not believed to be found anywhere within their historic range except Bear Lake (Utah Outdoors, 1999). A spawning trap has been established on Swan Creek to capture spawning Bonneville cutthroat each spring. Cutthroats entering the trap are stripped of eggs or milt, and combined to fertilize eggs. These eggs are taken to hatcheries to be raised. Most of the reared young are returned to the Bear Lake, but others are used to replenish other natal populations and are stocked out of their natural range as sport fish.

An estimated 31,000 Bonneville cutthroat (Ruzycki et al., 2001) were present in the lake in 1995. Populations of Bonneville cutthroat were in decline due to dewatering of spawning habitat and increased human exploitation. Conservation efforts by Utah Division of Wildlife Resources, Idaho Fish and Game, and U.S. Fish and Wildlife Services have reinvigorated the species and populations have been on the rise for over a decade (USFWS, 2001). Regulation is in place to protect the native fish and only allows harvest of marked hatchery raised fish. A limit of 2 total Bonneville cutthroats has been instrumental in increasing population levels.

Distribution of Bonneville cutthroat varies by season. Larger fish (>14 inches) are most often located in cooler waters, except during their spring spawning season. Smaller Bonneville cutthroat are associated with warmer temperatures when available (Wurtsbaugh and Hawkins, 1990). Bonneville cutthroat exhibit food preference shifts as they mature, starting with macro invertebrates, zooplankton and terrestrial insects they shift to Bear Lake sculpin and other small fishes, eventually graduating to a diet of primarily Bonneville cisco.

**Bonneville Cutthroat** *(Onchorhyncus clarki) Photo from:http://en.wikipedia.org/wiki/Image:Bonneville_cutthroat.jpg*

## *NATIVE NON-GAME*

Four species of native non-game species occupy Bear Lake, Utah Sucker (Catostomus ardens), speckled dace (Rhinichthys osculus), redside shiner (Richardsonius balteatus) and Utah chub (Gila atraria). Chub and suckers occupy benthic habitats. They have sub-terminal mouths designed for feeding on the bottom of the lake. The suckers occupy most depths in the lake where they feed on benthic invertebrates and detritus. The chub are restricted to shallow waters, usually less than 33 feet, and are often found to have plant matter in their guts along with benthic invertebrates (Wurtsbaugh and Hawkins, 1990).

Utah chub and suckers rarely turn up in the stomach of cutthroat or lake trout. The shallow dwelling practices of their young place them in habitats that are to warm for cold-water predators like trout. Suckers spawn in May and June on very shallow (< 3 feet deep) rock shores (Sigler and Sigler, 1987). Sucker eggs are preyed upon by sculpin and whitefish and are an important seasonal component of their diets. Little is know about chub reproduction in Bear Lake. Neither fish is considered a game fish (Sigler and Sigler, 1987).

Dace and shiners are small, “minnow” type fish that occupy shallow waters and are often associated with habitats provided by rocks and plants. Largest numbers are found near the Utah State Park marina and at shallow weed beds. Both species prey on invertebrates and zooplankton. Neither species is classed as a game fish, but could play a minor role as prey for trout and large whitefish. Humans do not pursue dace and shiners (Sigler and Sigler, 1987).

### *INTRODUCED*

Lake trout (Salvelinus namaycush) are native to the eastern United States, Canada and Alaska. They are a large piscivorous fish that can grow to weights over 70 pounds. They were introduced into Bear Lake in 1911 to increase sport-fishing opportunities and their population has been supplemented by intermittently stocking (Ruzycki, 2001). Lake trout weighing over 30 pounds are rare in Bear Lake due to low productivity. An extensive (1992-1994) population study by Ruzycki et al. (2001) estimated that there were 16,000 Lake trout age 4 and older in Bear Lake.

Stocking of fertile lake trout was greatly reduced after 1990 because of concern for native fishes that served as prey to their predators (Wurtsbaug and Luecke, 1993). Recently Lake trout stocking efforts have been reinitiated through the stocking of sterile triploid stock. These sterile Lake trout may grow faster in that energy used in reproduction will be shifted to growth, allow better control of population levels and increase Lake trout growth, as no energy will be used for gamete production (Oppedal et al, 2003).

**Lake Trout (S*alvelinus namaycush)***

*Photo: from www.ittiofauna.org*

Lake trout in Bear Lake feed on benthic and terrestrial invertebrates until they are large enough to switch to Bear Lake sculpin, which they consume exclusively until about age 4 when they become large enough to consume Bonneville cisco (Albrecht, 2004). Lake trout can live to ages of over 20 years and grow to lengths greater than 40 inches. Fishermen often exclusively target this game fish from shore and in boats.

Some researchers Ruzycki (2001), Wurtsbaugh and Hawkins (1990), Mazur and Beauchamp (1999), and Wurtsbaugh and Luecke (1998)) have speculated that Lake trout presence may reduce Bonneville cutthroat populations as they compete for limited resources. Albrecht et al. (2004) conducted a computer modeling study to analyze the effects of the stocking of sterile lake trout. Findings of field and computer studies suggest that lake trout and cutthroat trout likely compete for food resources that are limiting to the growth of these predators.

Three other species of fish have intentionally or accidentally been introduced into Bear Lake waters, where they survive in low numbers. They include green sunfish (Lepomus cyanellus), yellow perch (Perca flavescens) and the common carp (Cyprinus carpio). All 3 species can become nuisance invaders and have done so in other water bodies of the west. In Bear Lake these 3 fish have failed to thrive. Sunfish and perch populations are likely limited by a lack of suitable spawning sites, by low productivity, cool temperatures and predators. Carp numbers are kept low by cold water and lack of spawning habitat (UDWR, 2003).

Anglers fishing for trout or whitefish occasionally catch perch, but reports of this are not common. Sunfish are not reported to reach catchable lengths in Bear Lake and carp are not usually fished for in Bear Lake. Figure 12 shows a simplified food web as it can be represented in Bear Lake.

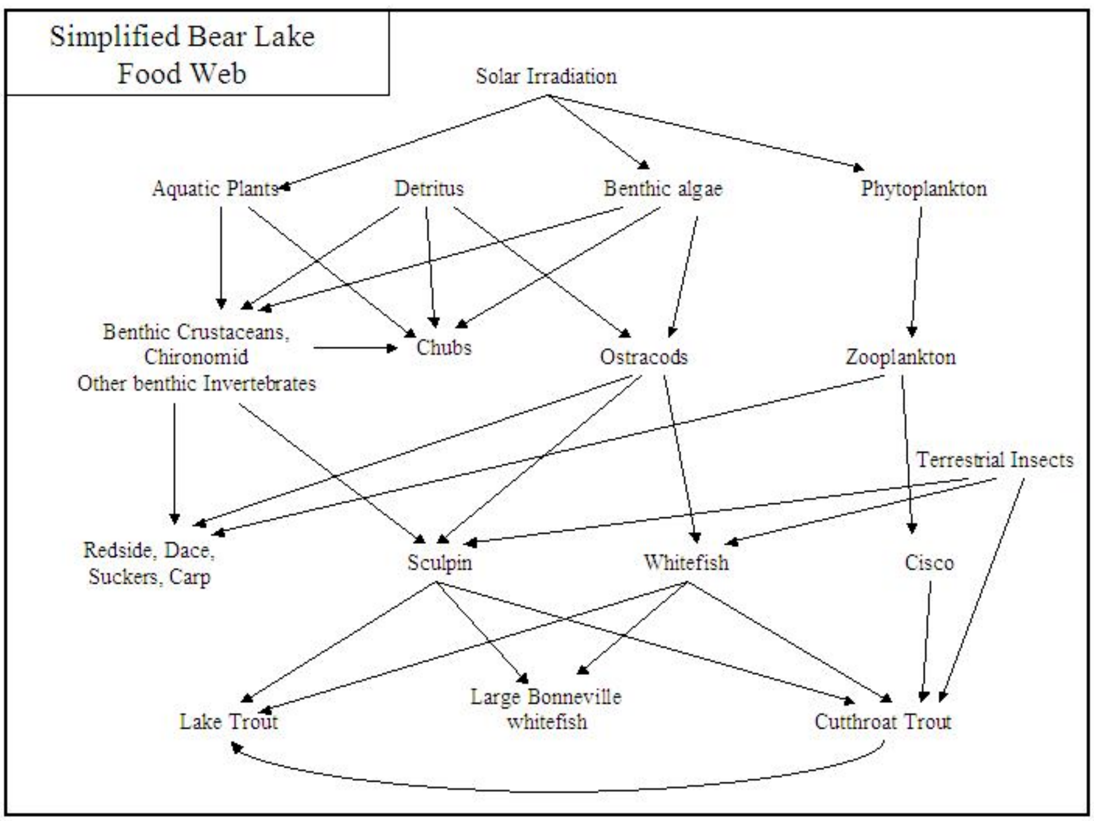



*Figure 12: Simplified Bear Lake Food Web.*

# BIRDS AND MAMMALS

Many bird species use Bear Lake seasonally or during migrations. Herons, egrets, sandpipers, rails, pelicans, geese, coots, grebes, Tundra swans and osprey are common visitors throughout the year. During the spring months of April through June the area becomes the primary breeding grounds for the burrowing owl, gray flycatcher, long-billed curlew, peregrine falcon, and the black-throated gray warbler. Early in the summer months, several species of mergansers and diving ducks converge on the rocky shorelines to fish as the newly hatched Bear Lake sculpin occupy shallow waters during this period. During winter the area becomes critical habitat for the American eagle and Swainson's hawk.

The uplands of Bear Lake Valley are home to many terrestrial birds including black-billed magpies, common ravens, broad-tailed hummingbirds, downy woodpeckers, European starlings, neo-tropical birds and introduced partridges and quail. Game species such as chukar, ruffled, and blue grouse populations are yearlong residents of the mountain brush in higher elevations where they nest and brood between April and July.

Bear Lake National Wildlife Refuge is a large natural preserve established on 19,000 acres of wetlands at the north end of Bear Lake. The main purpose of the refuge is to protect, restore and manage nesting habitat for waterfowl and other migratory birds. The Refuge is considered one of the most important resting and staging areas for migrating waterfowl in North America. In spring and summer, it is an extremely productive nesting area. The Audubon Society has identified the Bear Lake National Wildlife Refuge as an Important Bird Areas (IBA). The IBA Program identifies those places that are critical to birds during some part of their life cycle (breeding, wintering, feeding, migrating) in order to minimize the effects that habitat loss, and degradation have on bird populations. Read more about this program at http://www.audubon.org/bird/iba/index.html.

A partnership has been formed with the U.S. Fish and Wildlife service and Utah Power to work together to regulate the levels of water in the refuge. A checklist for bird species viewed within the refuge lists 160 species (U.S. Fish and Wildlife, 1993).


***Tundra Swans***
*Photo from: www.utahbirds.org*

The following table displays an inventory of bird species assigned to critical or high priority habitats as listed in the Utah Conservation Data Center (UCDC) central repository for Utah biodiversity information. Critical habitat is defined as "sensitive areas that, because of limited abundance and/or unique qualities, constitute irreplaceable, critical requirements for wildlife" (Edwards et al, 1995). This list excludes federally listed threatened and endangered species.

| Aquatic Birds | Birds of Prey | Terrestrial Birds |
|---|---|---|
| Wood duck | Western screech owl | Yellow-breasted chat |
| Wilson’s phalarope | Swainson’s hawk | Wren species |
| White-winged scoter | Rough legged hawk | Wilson’s snipe |
| Thayer’s gull | Red-tailed hawk | Western tanager |
| Surf scoter | Prairie falcon | Western meadowlark |
| Ruddy duck | Peregrine falcon | Warbler species |
| Ring-necked duck | Northern harrier | Townsend’s solitaire |
| Ring-billed gull | Long-eared owl | Swanson’s thrush |
| Red-necked phalarope | Golden eagle | Spotted snadpiper |
| Redhead | Ferruginous hawk | Sparrow species |
| Red-breasted merganser | Burrowing owl | Shrike species |
| Pacific loon | Barn owl | Say’s phoebe |
| Northern shoveler | American eagle | Sandhill crane |
| Northern pintail | American kestrel | Sage thrasher |
| Mallard | | Rock pigeon |
| Long-tailed duck | | Northern waterthrush |
| Long-billed dowitcher | | Northern mockingbird |
| Lesser scaup | | Mountain bluebird |
| Hooded merganser | | Killdeer |
| Herring gull | | Green tailed towhee |
| Glaucous gull | | Gray catbird |
| Franklin’s gull | | Common redpoll |
| Common merganser | | Common poorwill |
| Common loon | | Bushtit |
| Common goldeneye | | Bunting species |
| Cinnamon tell | | Bullock’s oriole |
| Canvasback | | Brown headed cowbird |
| California gull | | Brown creeper |
| Bufflehead | | Brewer’s blackbird |
| Bonaparte’s gull | | Black-capped chickadee |
| American coot | | American robin |
| | | American redstart |

*Table 15. Bird Species Present in the Bear Lake Basin With Critical or High Priority Designation (http://dwrcdc.nr.utah.gov/ucdc/default.asp).*

Many other animal species use the areas surrounding Bear Lake as habitat. The big game species include mule deer, elk, moose, North American pronghorn, mountain lion and coyote. Black bear, though very limited in concentration, are thought to be located on the eastern side of the Lake in U.S. Forest Service Land (BLRC, 2004).

Portions of Rich County provide habitat for several species of furbearers; ground squirrels and pocket gophers, chipmunks, squirrels, skunks, mice/ shrews/ voles, cottontail and jackrabbits, badgers, weasels, bobcats, muskrats and river otters, and raccoons. The snowshoe hare is dependent upon the conifer vegetation above the Lake and the prairie dog colonies along the western edge are noted as supporting the historic black-footed ferret range.

Amphibians with critical habitat include the western chorus frog, northern leopard frog, tiger salamander, Great Basin spadefoot, Columbia spotted frog, and the Woodhouse's toad. The western toad, pictured below, appears on Utah's sensitive species list with an unconfirmed status.

The few reptiles that are common in the basin area are the Great Basin rattlesnake, common and terrestrial garter snakes, striped whipsnake, western skink, gopher snake, Eastern racer and common sagebrush lizard.

**Western Toad (Bufo boreas)**
*Photo from Chris Brown at*
*http://www.werc.usgs.gov/fieldguide/bubo.htm*

## *THREATENED AND ENDANGERED*

Endangered, threatened, and species of special concern use Bear Lake and its surrounding habitats. Bald eagles and white pelicans stop near the lakeshore to fish and rest during migrations. Grey wolves are expected to be returning to the area as they expand outward from Yellowstone National Park. Numerous bird species on Utah's list of special concern may be residing in the hills surrounding Bear Lake. One of the three strongest sage grouse populations of Utah resides on in the sagebrush steppe to the east of Bear Lake. Pygmy rabbits are found in the tall sage forests around the lakeshore and surrounding areas.  Bear Lake spring snails are endemic to the valley and are protected by both Utah and Idaho. For a complete list of special status species that reside in the Bear Lake Valley see Table 16.

**Wolves venturing into Utah**
*Photo from: http://www.defenders.org/den/dl00082.html*

| Common Name | Scientific name | Current Status |
|---|---|---|
| **Federally Endangered Species** | | |
| Black-footed ferret | Mustela nigripe | E |
| Gray wolf | Canis lupus | E |
| Utah valvata | Valvata utahensis | U |
| **Federally Threatened Species** | | |
| Brown/grizzly bear | Ursus arctos | E |
| Canada lynx | Lynx Canadensis | U |
| Bald Eagle | Haliaeetus leucocephalus | P-seasonal |
| **Conservation Agreement Species** | | |
| Bonneville cutthroat trout | Oncorhynchus clarki utah | C |
| Northern Goshawk | Accipiter gentiles | R |
| **Wildlife Species of Concern** | | |
| *Fish* | | |
| Leatherside chub | Gila copei | U |
| Bear Lake whitefish | Prosopium abyssicola | C |
| Bonneville cisco | Prosopium gemmifer | C |
| Bonneville whitefish | Prosopium spilonotus | C |
| Bear Lake sculpin | Cottus extensus | C |
| *Amphibians* | | |
| Western toad | Bufo boreas | U |
| *Birds* | | |
| Grasshopper Sparrow | Ammodramus savannarum | R |
| Short-eared Owl | Asio flammeus | U |
| Ferruginous Hawk | Buteo regalis | R |
| Greater Sage-grouse | Centrocercus urophasianus | P |
| Bobolink | Dolichonyx oryzivorus | U |
| American White Pelican | Pelecanus erythrorhynchos | R |
| Three-toed Woodpecker | Picoides tridactylus | U |
| Sharp-tailed Grouse | Tympanuchus phasianellus | E |
| *Mammals* | | |
| Townsend's big-eared bat | Corynorhinus townsendii | P |
| Pygmy rabbit | Brachylagus idahoensis | C |
| White-tailed Prairie-dog | Cynomys leucurus | |
| *Mollusks* | | |
| Bear Lake springsnail | Pyrgulopsis pilsbryana | R |
| Lyrate mountain snail | Oreohelix haydeni | U |
| Western pearlshell | Margaritifera falcate | U |

*Table 16. Utah's Sensitive Species List. Status is listed above each group. Abbreviations:. E = Extirpated, U = unknown/unconfirmed, R = Rare, P = Present, and C = Common ((dwrcdc.nr.utah.gov/ucdc, 2006).*

# PALEO-BIOLOGY

Many ancient clam and snail shells have been found around the shoreline of Bear Lake. Local residents have at times gathered the shells as a source of calcium for their chickens. These shells are well preserved and have been dated to be 10,000 years old (Smart, 1963). Curators at the Smithsonian Institute identified all 6 species of snail and one species of clam. Carbon dating performed by Columbia University estimated shells gathered from the Ideal Beach area of Bear Lake to be 12,000 years old. During this era (Pleistocene) waters around the west were at much higher levels. Bear Lake was estimated to be 33 feet above current high water marks (Smart, 1963). Increased lake elevation flooded much of the north end of the Bear Lake valley and lowered the water hardness creating extensive warm, productive shallow areas ideal for mollusk growth. A dry period (~ 4,000–5,000 years ago) reduced the water level of Bear Lake. Increases in water hardness and lowered productivity caused the extirpation of these large mollusks.

The California floater has historically been found in the Bear Lake area. It is considered a species of concern due to reductions in population and range. No live specimens have been found in the area for many years. Another mussel that historically was found in small streams in the Bear Lake area is the western pearlshell. It is also a species of concern, and it is unclear if it still exists in the area (Utah Division of Parks and Recreation, 2005).

The shells of a freshwater mussel *Anodonta oregonensis* can be found in erosional zones of the margin of the lake. Recent sightings of live specimens have been reported anecdotally, but no recent official documentation of the mussel has been accomplished. *A. oregonensis* was likely extirpated. Currently there are 2 mollusks in the lake, a small pisid clam and an unidentified *valvata* snail, both are found in low density in the upper half of the lake's benthos (Kennedy, 2005).

# PALEO-HYDROLOGY

Bear Lake has many advantages for recording the history of climate change in the western United States. The deep lake provides nearly 250,000 years of continuous sedimentary sequence. Bear Lake has experienced large fluctuations in elevation over time. Laabs and Kaufman (2003) suggest that during the Pleistocene era, 15,000-10,000 years ago, the lake elevation was estimated to be at 6000 feet above sea level, a full 76 feet above current high levels. Further evidence uncover that the surrounding wetlands transgressed at least 3 times to 5,960 feet, 5,950 feet and 5,935 feet (Laabs, 2003).

The transition from clay-rich sediment to aragonitic mud records the change from a lake dominated by inflow of the Bear River during the Pleistocene to a groundwater-fed lake during the Holocene. Root structures in sediments require very shallow water or subaerial exposure. Carbon dates indicate that they formed before 7,000 BP. These dates are similar to periods of severe drought in other Great Basin Lakes (Smoot, 2002).

Bear Lake has been disconnected from Bear River inflow for at least 8,000 years. During isolation the only water sources entering the lake are from springs, local runoff, and precipitation. Holocene era (10,000 years ago to present) was a time of large fluctuations in water cycles in the intermountain west. Drought cycles and disconnection from Bear River waters lead to low Bear Lake water levels that would have averaged 45 feet lower than historic averages. Similar hydrological regimes during this era have been documented from other regions of the west by using tree ring analysis (Rosenbaum, 2004).

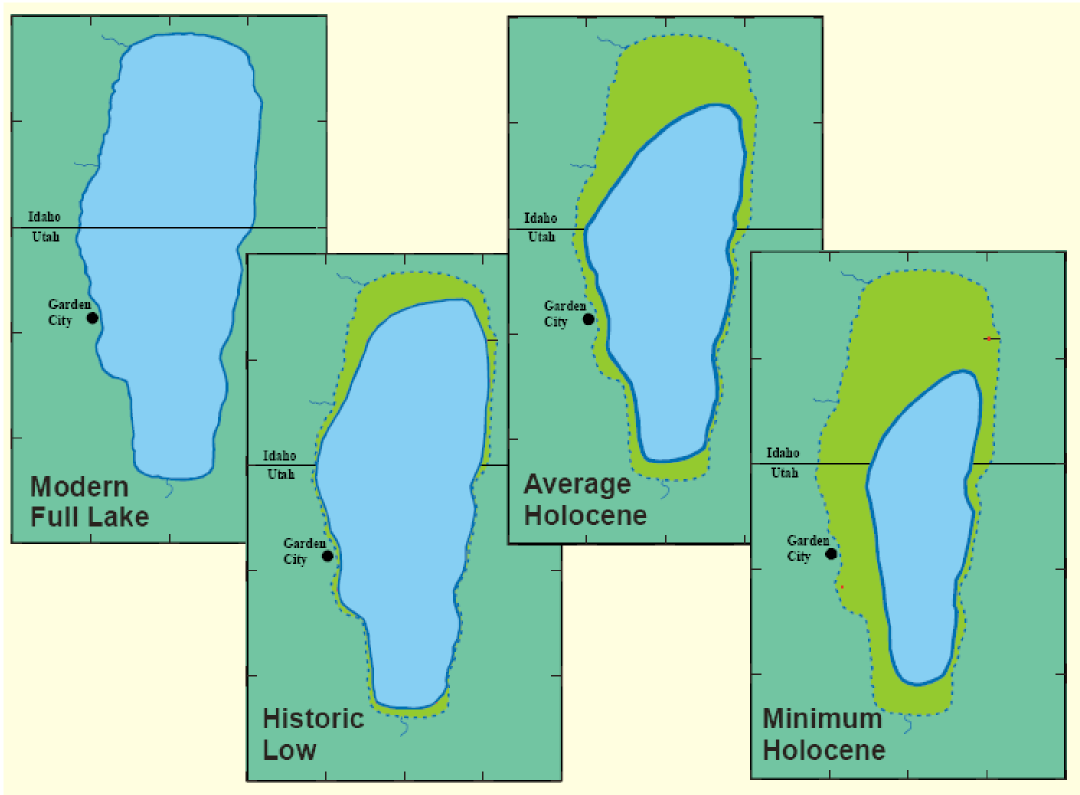



*Figure 13. Estimates of Bear Lake Fullness During the Last 10,000 years (Holocene era). From sediment coring analysis of the United States Geological Survey (http://www.bearlakewatch.com/Bear_Lake_EcoSym/rosenbaum.pdf).*

Estimates of Bear Lake water levels during the last 30,000 years indicate that the Bear River has flown intermittently into Bear Lake. Dominant sediments in cores indicated that Bear River water flowed into Bear Lake from 30,000-17,000; from 14,000-11,000; and from 9,000-8,000 year ago (Rosenbaum, 2004).

Using a network of high-resolution seismic reflection profiles, a sonar mosaic and bathymetric map was created to access sublacustrine spring discharge and fault scarps on the lake floor. Numerous springs and vents occur along the southern part of the east and west shoreline at depth of 30-50 feet have been revealed and diagramed. (Denny, 2002).

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# APPENDIX A

**Bear River Compact**
**Utah Code Title 73, Chapter 16**

73-16-1. Ratification.
The Bear River Compact entered into at Salt Lake City, Utah, on February 4, 1955, by Idaho, Utah and Wyoming, by the representatives of those states, with the approval of the representative of the United States of America, is hereby unconditionally ratified, approved and confirmed for and by the state of Utah.
73-16-2. Text of compact.
The text of the Bear River Compact is as follows:

**AMENDED BEAR RIVER COMPACT**

The State of Idaho, the State of Utah and the State of Wyoming, acting through their respective Commissioners after negotiations participated in by a representative of the United States of America appointed by the President, have agreed to an Amended Bear River Compact as follows:

**ARTICLE I**

A. The major purposes of this Compact are to remove the causes of present and future controversy over the distribution and use of the waters of the Bear River; to provide for efficient use of water for multiple purposes; to permit additional development of the water resources of Bear River; to promote interstate comity; and to accomplish an equitable apportionment of the waters of the Bear River among the compacting States.
B. The physical and all other conditions peculiar to the Bear River constitute the basis for this Compact. No general principle or precedent with respect to any other interstate stream is intended to be established.

**ARTICLE II**

As used in this Compact the term
1. "Bear River" means the Bear River and its tributaries from its source in the Uinta Mountains to its mouth in Great Salt Lake;
2. "Bear Lake" means Bear Lake and Mud Lake;
3. "Upper Division" means the portion of Bear River from its source in the Uinta Mountains to and including Pixley Dam, a diversion dam in the Southeast Quarter of Section 25, Township 23 North, Range 120 West, Sixth Principal Meridian, Wyoming;
4. "Central Division" means the portion of Bear River from Pixley Dam to and including Stewart Dam, a diversion dam in Section 34, Township 13 South, Range 44 East, Boise Base and Meridian, Idaho;
5. "Lower Division" means the portion of the Bear River between Stewart Dam and Great Salt Lake, including Bear Lake and its tributary drainage;
6. "Upper Utah Section Diversions" means the sum of all diversions in second-feet from the Bear River and the tributaries of the Bear River joining the Bear River upstream from the point where the Bear River crosses the Utah-Wyoming State line above Evanston, Wyoming; excluding the diversions by the Hilliard East Fork Canal, Lannon Canal, Lone Mountain Ditch, and Hilliard West Side Canal;

7. "Upper Wyoming Section Diversions" means the sum of all diversions in second-feet from the Bear River main stem from the point where the Bear River crosses the Utah-Wyoming State line above Evanston, Wyoming, to the point where the Bear River crosses the Wyoming-Utah State line east of Woodruff, Utah, and including the diversions by the Hilliard East Fork Canal, Lannon Canal, Lone Mountain Ditch, and Hilliard West Side Canal;
8. "Lower Utah Section Diversions" means the sum of all diversions in second-feet from the Bear River main stem from the point where the Bear River crosses the Wyoming-Utah State line east of Woodruff, Utah, to the point where the Bear River crosses the Utah-Wyoming State line northeast of Randolph, Utah;
9. "Lower Wyoming Section Diversions" means the sum of all diversions in second-feet from the Bear River main stem from the point where the Bear River crosses the Utah-Wyoming
State line northeast of Randolph to and including the diversion at Pixley Dam;
10. "Commission" means the Bear River Commission, organized pursuant to Article III of this Compact;
11. "Water user" means a person, corporation, or other entity having a right to divert water from the Bear River for beneficial use;
12. "Second-foot" means a flow of one cubic foot of water per second of time passing a given point;
13. "Acre-foot" means the quantity of water required to cover one acre to a depth of one foot, equivalent to 43,560 cubic feet;
14. "Biennium" means the 2-year period commencing on October 1 of the first odd-numbered year after the effective date of this Compact and each 2-year period thereafter;
15. "Water year" means the period beginning October 1 and ending September 30 of the following year;
16. "Direct flow" means all water flowing in a natural watercourse except water released from storage or imported from a source other than the Bear River watershed;
17. "Border Gaging Station" means the stream flow gaging station in Idaho on the Bear River above Thomas Fork near the Wyoming-Idaho boundary line in the Northeast Quarter of the Northeast Quarter of Section 15, Township 14 South, Range 46 East, Boise Base and Meridian, Idaho;
18. "Smiths Fork" means a Bear River tributary which rises in Lincoln County, Wyoming, and flows in a general southwesterly direction to its confluence with Bear River near Cokeville, Wyoming;
19. "Grade Creek" means a Smiths Fork tributary which rises in Lincoln County, Wyoming, and flows in a westerly direction and in its natural channel is tributary to Smiths Fork in Section 17, Township 25 North, Range 118 West, Sixth Principal Meridian, Wyoming;
20. "Pine Creek" means a Smiths Fork tributary which rises in Lincoln County, Wyoming, emerging from its mountain canyon in Section 34, Township 25 North, Range 118 West, Sixth Principal Meridian, Wyoming, and its natural channel is tributary to Smiths Fork in Section 36, Township 25 North, Range 119 West, Sixth Principal Meridian, Wyoming;
21. "Bruner Creek" and "Pine Creek Springs" means Smiths Fork tributaries which rise in Lincoln County, Wyoming, in Sections 31 and 32, Township 25 North, Range

118 West, Sixth Principal Meridian, and in their natural channels are tributary to Smiths Fork in Section 36, Township 25 North, Range 119 West, Sixth Principal Meridian, Wyoming;

22. "Spring Creek" means a Smiths Fork tributary which rises in Lincoln County, Wyoming, in Sections 1 and 2, Township 24 North, Range 119 West, Sixth Principal Meridian, Wyoming, and flows in a general westerly direction to its confluence with Smiths Fork in Section 4, Township 24 North, Range 119 West, Sixth Principal Meridian, Wyoming;

23. "Sublette Creek" means the Bear River tributary which rises in Lincoln County, Wyoming, and flows in a general westerly direction to its confluence with Bear River in Section 20, Township 24 North, Range 119 West, Sixth Principal Meridian, Wyoming;

24. "Hobble Creek" means the Smiths Fork tributary which rises in Lincoln County, Wyoming, and flows in a general southwesterly direction to its confluence with Smiths Fork in Section 35, Township 28 North, Range 118 West, Sixth Principal Meridian, Wyoming;

25. "Hilliard East Fork Canal" means that irrigation canal which diverts water from the right bank of the East Fork of Bear River in Summit County, Utah, at a point West 1,310 feet and
North 330 feet from the Southeast corner of Section 16, Township 2 North, Range 10 East, Salt Lake Base and Meridian, Utah, and runs in a northerly direction crossing the Utah-Wyoming State line into the Southwest Quarter of Section 21, Township 12 North, Range 119 West, Sixth Principal Meridian, Wyoming;

26. "Lannon Canal" means that irrigation canal which diverts water from the right bank of the Bear River in Summit County, Utah, East 1,480 feet from the West Quarter corner of Section 19, Township 3 North, Range 10 East, Salt Lake Base and Meridian, Utah, and runs in a northerly direction crossing the Utah-Wyoming State line into the South Half of Section 20, Township 12 North, Range 119 West, Sixth Principal Meridian, Wyoming;

27. "Lone Mountain Ditch" means that irrigation canal which diverts water from the right bank of the Bear River in Summit County, Utah, North 1,535 feet and East 1,120 feet from the West Quarter corner of Section 19, Township 3 North, Range 10 East, Salt Lake Base and Meridian, Utah, and runs in a northerly direction crossing the Utah-Wyoming State line into the South Half of Section 20, Township 12 North, Range 119 West, Sixth Principal Meridian, Wyoming;

28. "Hilliard West Side Canal" means that irrigation canal which diverts water from the right bank of the Bear River in Summit County, Utah, at a point North 2,190 feet and East 1,450 feet from the South Quarter corner of Section 13, Township 3 North, Range 9 East, Salt Lake Base and Meridian, Utah, and runs in a northerly direction crossing the Utah Wyoming State line into the South Half of Section 20, Township 12 North, Range 119 West, Sixth Principal Meridian, Wyoming;

29. "Francis Lee Canal" means that irrigation canal which diverts water from the left bank of the Bear River in Uinta County, Wyoming, in the Northeast Quarter of Section 30, Township 18 North, Range 120 West, Sixth Principal Meridian, Wyoming, and runs in a westerly direction across the Wyoming-Utah State line into Section 16, Township 9 North, Range 8 East, Salt Lake Base and Meridian, Utah;

30. "Chapman Canal" means that irrigation canal which diverts water from the left bank of the Bear River in Uinta County, Wyoming, in the Northeast Quarter of

Section 36, Township 16 North, Range 121 West, Sixth Principal Meridian, Wyoming, and runs in a northerly direction crossing over the low divide into the Saleratus drainage basin near the Southeast corner of Section 36, Township 17 North, Range 121 West, Sixth Principal Meridian, Wyoming, and then in a general westerly direction crossing the Wyoming-Utah State line;
31. "Neponset Reservoir" means that reservoir located principally in Sections 34 and 35, Township 8 North, Range 7 East, Salt Lake Base and Meridian, Utah, having a capacity of 6,900 acre-feet.

**ARTICLE III**

A. There is hereby created an interstate administrative agency to be known as the "Bear River Commission" which is hereby constituted a legal entity and in such name shall exercise the powers hereinafter specified. The Commission shall be composed of nine Commissioners, three Commissioners representing each signatory State, and if appointed by the President, one additional Commissioner representing the United States of America who shall serve as chairman, without vote. Each Commissioner, except the chairman, shall have one vote. The State Commissioners shall be selected in accordance with State law. Six Commissioners who shall include two Commissioners from each State shall constitute a quorum. The vote of at least two-thirds of the Commissioners when a quorum is present shall be necessary for the action of the Commission.
B. The compensation and expenses of each Commissioner and each adviser shall be paid by the government which he represents. All expenses incurred by the Commission in the administration of this Compact, except those paid by the United States of America, shall be paid by the signatory States on an equal basis.
C. The Commission shall have power to:
1. Adopt bylaws, rules, and regulations not inconsistent with this Compact;
2. Acquire, hold, convey or otherwise dispose of property;
3. Employ such persons and contract for such services as may be necessary to carry out its duties under this Compact;
4. Sue and be sued as a legal entity in any court of record of a signatory State, and in any court of the United States having jurisdiction of such action;
5. Co-operate with State and Federal agencies in matters relating to water pollution of interstate significance;
6. Perform all functions required of it by this Compact and do all things necessary, proper or convenient in the performance of its duties hereunder, independently or in cooperation with others, including State and Federal agencies.
D. The Commission shall:
1. Enforce this Compact and its orders made hereunder by suit or other appropriate action;
2. Compile a report covering the work of the Commission and expenditures during the current biennium, and an estimate of expenditures for the following biennium and transmit it to the President of the United States and to the Governors of the signatory States on or before July 1 following each biennium.

## ARTICLE IV

Rights to direct flow water shall be administered in each signatory State under state law, with the following limitations:

A. When there is a water emergency, as hereinafter defined for each division, water shall be distributed therein as provided below.

1. Upper Division.

a. When the divertible flow as defined below for the upper division is less than 1,250 second-feet, a water emergency shall be deemed to exist therein and such divertible flow is allocated for diversion in the river sections of the Division as follows:

Upper Utah Section Diversions - 0.6%,
Upper Wyoming Section Diversions - 49.3%,
Lower Utah Section Diversions - 40.5%,
Lower Wyoming Section Diversions - 9.6%.

Such divertible flow shall be the total of the following five items:

(1) Upper Utah Section Diversions in second-feet,
(2) Upper Wyoming Section Diversions in second-feet,
(3) Lower Utah Section Diversions in second-feet,
(4) Lower Wyoming Section Diversions in second-feet,
(5) The flow in second-feet passing Pixley Dam.

b. The Hilliard East Fork Canal, Lannon Canal, Lone Mountain Ditch, and Hilliard West Side Canal, which divert water in Utah to irrigate lands in Wyoming, shall be supplied from the divertible flow allocated to the Upper Wyoming Section Diversions.

c. The Chapman, Bear River, and Francis Lee Canals, which divert water from the main stem of Bear River in Wyoming to irrigate lands in both Wyoming and Utah, shall be supplied from the divertible flow allocated to the Upper Wyoming Section Diversions.

d. The Beckwith Quinn West Side Canal, which diverts water from the main stem of Bear River in Utah to irrigate lands in both Utah and Wyoming, shall be supplied from the divertible flow allocated to the Lower Utah Section Diversions.

e. If for any reason the aggregate of all diversions in a river section of the Upper Division does not equal the allocation of water thereto, the unused portion of such allocation shall be available for use in the other river sections in the Upper Division in the following order: (1) In the other river section of the same State in which the unused allocation occurs; and (2) In the river sections of the other State. No permanent right of use shall be established by the distribution of water pursuant to this paragraph e.

f. Water allocated to the several sections shall be distributed in each section in accordance with State law.

2. Central Division.

a. When either the divertible flow as hereinafter defined for the Central Division is less than 870 second-feet, or the flow of the Bear River at Border Gaging Station is less than 350 second-feet, whichever shall first occur, a water emergency shall be deemed to exist in the Central Division and the total of all diversions in Wyoming from Grade Creek, Pine Creek, Bruner Creek and Pine Creek Springs, Spring Creek, Sublette Creek, Smiths Fork, and all the tributaries of Smiths Fork above the mouth of Hobble Creek including Hobble Creek, and from the main stem of the

Bear River between Pixley Dam and the point where the river crosses the Wyoming-Idaho State line near Border shall be limited for the benefit of the State of Idaho, to not exceed 43% of the divertible flow. The remaining 57% of the divertible flow shall be available for use in Idaho in the Central Division, but if any portion of such allocation is not used therein it shall be available for use in Idaho in the Lower Division.

The divertible flow for the Central Division shall be the total of the following three items:

(1) Diversions in second-feet in Wyoming consisting of the sum of all diversions from Grade Creek, Pine Creek, Bruner Creek and Pine Creek Springs, Spring Creek, Sublette Creek, and Smiths Fork and all the tributaries of Smiths Fork above the mouth of Hobble Creek including Hobble Creek, and the main stem of the Bear River between Pixley Dam and the point where the river crosses the Wyoming-Idaho State line near Border, Wyoming.

(2) Diversions in second-feet in Idaho from the Bear River main stem from the point where the river crosses the Wyoming-Idaho State line near Border to Stewart Dam including West Fork Canal which diverts at Stewart Dam.

(3) Flow in second-feet of the Rainbow Inlet Canal and of the Bear River passing downstream from Stewart Dam.

b. The Cook Canal, which diverts water from the main stem of the Bear River in Wyoming to irrigate lands in both Wyoming and Idaho, shall be considered a Wyoming diversion and shall be supplied from the divertible flow allocated to Wyoming.

c. Water allocated to each State shall be distributed in accordance with State law.

3. Lower Division.

a. When the flow of water across the Idaho-Utah boundary line is insufficient to satisfy water rights in Utah, covering water applied to beneficial use prior to January 1, 1976, any water user in Utah may file a petition with the Commission alleging that by reason of diversions in Idaho he is being deprived of water to which he is justly entitled, and that by reason thereof, a water emergency exists, and requesting distribution of water under the direction of the Commission. If the Commission finds a water emergency exists, it shall put into effect water delivery schedules based on priority of rights and prepared by the Commission without regard to the boundary line for all or any part of the Division, and during such emergency, water shall be delivered in accordance with such schedules by the State official charged with the administration of public waters.

B. The Commission shall have authority upon its own motion (1) to declare a water emergency in any or all river divisions based upon its determination that there are diversions which violate this Compact and which encroach upon water rights in a lower State, (2) to make appropriate orders to prevent such encroachments, and (3) to enforce such orders by action before State administrative officials or by court proceedings.

C. When the flow of water in an interstate tributary across a State boundary line is insufficient to satisfy water rights on such tributary in a lower State, any water user may file a petition with the Commission alleging that by reason of diversions in an upstream State he is being deprived of water to which he is justly entitled and that by reason thereof a water emergency exists, and requesting distribution of water under the direction of the Commission. If the Commission finds that a water

emergency exists and that interstate control of water of such tributary is necessary, it shall put into effect water delivery schedules based on priority of rights and prepared without regard to the State boundary line. The State officials in charge of water distribution on interstate tributaries may appoint and fix the compensation and expenses of a joint water commissioner for each tributary. The proportion of the compensation and expenses to be paid by each State shall be determined by the ratio between the number of acres therein which are irrigated by diversions from such tributary, and the total number of acres irrigated from such tributary.
D. In preparing interstate water delivery schedules the Commission, upon notice and after public hearings, shall make finding of fact as to the nature, priority and extent of water rights, rates of flow, duty of water, irrigated acreages, types of crops, time of use, and related matters; provided that such schedules shall recognize and incorporate therein priority of water rights as adjudicated in each of the signatory States. Such findings of fact shall, in any court or before any tribunal, constitute prima facie evidence of the facts found.
E. Water emergencies provided for herein shall terminate on September 30 of each year unless terminated sooner or extended by the Commission.

**ARTICLE V**

A. Water rights in the Lower Division acquired under the laws of Idaho and Utah covering water applied to beneficial use prior to January 1, 1976, are hereby recognized and shall be administered in accordance with State law based on priority of rights as provided in Article IV, paragraph A3. Rights to water first applied to beneficial use on or after January 1, 1976, shall be satisfied from the respective allocations made to Idaho and Utah in this paragraph and the water allocated to each State shall be administered in accordance with State law. Subject to the foregoing provisions, the remaining water in the Lower Division, including ground water tributary to the Bear River, is hereby apportioned for use in Idaho and Utah as follows:

(1) Idaho shall have the first right to the use of such remaining water resulting in an annual depletion of not more than 125,000 acre-feet.

(2) Utah shall have the second right to the use of such remaining water resulting in an annual depletion of not more than 275,000 acre-feet.

(3) Idaho and Utah shall each have an additional right to deplete annually on an equal basis, 75,000 acre-feet of the remaining water after the rights provided by subparagraphs (1), and (2) above have been satisfied.

(4) Any remaining water in the Lower Division after the allocations provided for in subparagraphs (1), (2), and (3) above have been satisfied shall be divided; 30% to Idaho and 70% to Utah.

B. Water allocated under the above subparagraphs shall be charged against the State in which it is used regardless of the location of the point of diversion.
C. Water depletions permitted under provisions of subparagraphs (1), (2), and (3), and (4) above, shall be calculated and administered by a Commission-approved procedure.

**ARTICLE VI**

A. Existing storage rights in reservoirs constructed above Stewart Dam prior to February 4, 1955, are as follows:

Idaho............................................................................................324 acre-feet
Utah...........................................................................................11,850 acre-feet
Wyoming.....................................................................................2,150 acre-feet

Additional rights are hereby granted to store in any water year above Stewart Dam, 35,500 acre-feet of Bear River water and no more under this paragraph for use in Utah and Wyoming; and to store in any water year in Idaho or Wyoming on Thomas Fork 1,000 acre-feet of water for use in Idaho. Such additional storage rights shall be subordinate to, and shall not be exercised when the effect thereof will be to impair or interfere with (1) existing direct flow rights for consumptive use in any river division and (2) existing storage rights above Stewart Dam, but shall not be subordinate to any right to store water in Bear Lake or elsewhere below Stewart Dam. One-half of the 35,500 acre-feet of additional storage right above Stewart Dam so granted to Utah and Wyoming is hereby allocated to Utah, and the remaining one-half thereof is allocated to Wyoming.

B. In addition to the rights defined in Paragraph A of this Article, further storage entitlements above Stewart Dam are hereby granted. Wyoming and Utah are granted an additional right to store in any year 70,000 acre-feet of Bear River water for use in Utah and Wyoming to be divided equally; and Idaho is granted an additional right to store 4,500 acre-feet of Bear River water in Wyoming or Idaho for use in Idaho. Water rights granted under this paragraph and water appropriated, including ground water tributary to Bear River, which is applied to beneficial use on or after January 1, 1976, shall not result in an annual increase in depletion of the flow of the Bear River and its tributaries above Stewart Dam of more than 28,000 acre-feet in excess of the depletion as of January 1, 1976. Thirteen thousand (13,000) acre-feet of the additional depletion above Stewart Dam is allocated to each of Utah and Wyoming, and two thousand (2,000) acre-feet is allocated to Idaho.

The additional storage rights provided for in this Paragraph shall be subordinate to, and shall not be exercised when the effect thereof will be to impair or interfere with (1) existing direct flow rights for consumptive use in any river division and (2) existing storage rights above Stewart Dam, but shall not be subordinate to any right to store water in Bear Lake or elsewhere below Stewart Dam; provided, however, there shall be no diversion of water to storage above Stewart Dam under this Paragraph B when the water surface elevation of Bear Lake is below 5,911.00 feet, Utah Power & Light Company datum (the equivalent of elevation 5,913.75 feet based on the sea level datum of 1929 through the Pacific Northwest Supplementary Adjustment of 1947). Water depletions permitted under this Paragraph B shall be calculated and administered by a Commission-approved procedure.

C. In addition to the rights defined in Article VI, Paragraphs A and B, Idaho, Utah and Wyoming are granted the right to store and use water above Stewart Dam that otherwise would be bypassed or released from Bear Lake at times when all other direct flow and storage rights are satisfied. The availability of such water and the operation of reservoir space to store water above Bear Lake under this paragraph shall be determined by a Commission-approved procedure. The storage provided for in this Paragraph shall be subordinate to all other storage and direct flow rights in the Bear River. Storage rights under this Paragraph shall be exercised with equal priority on the following basis: 6% thereof to Idaho; 47% thereof to Utah; and 47% thereof to Wyoming.

D. The waters of Bear Lake below elevation 5,912.91 feet, Utah Power and Light Company Bear Lake datum (the equivalent of elevation 5,915.66 feet based on the sea level datum of 1929 through the Pacific Northwest Supplementary Adjustment of 1947) shall constitute a reserve for irrigation. The water of such reserve shall not be released solely for the generation of power, except in emergency, but after release for irrigation it may be used in generating power if not inconsistent with its use for irrigation. Any water in Bear Lake in excess of that constituting the irrigation reserve may be used for the generation of power or for other beneficial uses. As new reservoir capacity above the Stewart Dam is constructed to provide additional storage pursuant to Paragraph A of this Article, the Commission shall make a finding in writing as to the quantity of additional storage and shall thereupon make an order increasing the irrigation reserve in accordance with the following table:

| Additional Storage Acre-feet | Lake surface elevation Utah Power & Light Company Bear Lake datum |
|---|---|
| 5,000 | 5,913.24 |
| 10,000 | 5,913.56 |
| 5,000 | 5,913.87 |
| 20,000 | 5,914.15 |
| 25,000 | 5,914.41 |
| 30,000 | 5,914.61 |
| 35,500 | 5,914.69 |
| 36,500 | 5,914.70 |

E. Subject to existing rights, each State shall have the use of water, including groundwater, for ordinary domestic, and stock watering purposes, as determined by State law and shall have the right to impound water for such purposes in reservoirs having storage capacities not in excess, in any case, of 20 acre-feet, without deduction from the allocation made by paragraphs A, B, and C of this Article.

F. The storage rights in Bear Lake are hereby recognized and confirmed subject only to the restrictions hereinbefore recited.

**ARTICLE VII**

It is the policy of the signatory States to encourage additional projects for the development of the water resources of the Bear River to obtain the maximum beneficial use of water with a minimum of waste, and in furtherance of such policy, authority is granted within the limitations provided by this Compact, to investigate, plan, construct, and operate such projects without regard to State boundaries, provided that water rights for each such project shall, except as provided in Article VI, Paragraphs A and B, thereof, be subject to rights theretofore initiated and in good standing.

**ARTICLE VIII**

A. No State shall deny the right of the United States of America, and subject to the conditions hereinafter contained, no State shall deny the right of another signatory State, any person or entity of another signatory State, to acquire rights to the use of water or to construct or to participate in the construction and use of diversion works and storage reservoirs with appurtenant works, canals, and conduits in one State for use of water in another State, either directly or by exchange. Water rights acquired for out-of-state use shall be appropriated in the State where the point of diversion is located in the manner provided by law for appropriation of water for use within such State.

B. Any signatory State, any person or any entity of any signatory State, shall have the right to acquire in any other signatory State such property rights as are necessary to the use of water in conformity with this Compact by donation, purchase, or, as hereinafter provided through the exercise of the power of eminent domain in accordance with the law of the State in which such property is located. Any signatory State, upon the written request of the Governor of any other signatory State for the benefit of whose water users property is to be acquired in the State to which such written request is made, shall proceed expeditiously to acquire the desired property either by purchase at a price acceptable to the requesting Governor, or if such purchase cannot be made, then through the exercise of its power of eminent domain and shall convey such property to the requesting State or to the person, or entity designated by its Governor provided, that all costs of acquisition and expenses of every kind and nature whatsoever incurred in obtaining such property shall be paid by the requesting State or the person or entity designated by its Governor.

C. Should any facility be constructed in a signatory State by and for the benefit of another signatory State or persons or entities therein, as above provided, the construction, repair, replacement, maintenance and operation of such facility shall be subject to the laws of the State in which the facility is located.

D. In the event lands or other taxable facilities are acquired by a signatory State in another signatory State for the use and benefit of the former, the users of the water made available by such facilities, as a condition precedent to the use thereof, shall pay to the political subdivisions of the State in which such facilities are located, each and every year during which such rights are enjoyed for such purposes, a sum of money equivalent to the average of the amount of taxes annually levied and assessed against the land and improvements thereon during the ten years preceding the acquisition of such land. Said payments shall be in full reimbursement for the loss of taxes in such political subdivision of the State.

E. Rights to the use of water acquired under this Article shall in all respects be subject to this Compact.

**ARTICLE IX**

Stored water, or water from another watershed may be turned into the channel of the Bear River in one State and a like quantity, with allowance for loss by evaporation, transpiration, and seepage, may be taken out of the Bear River in another State either above or below the point where the water is turned into the channel, but in making such exchange the replacement water shall not be inferior in quality for the purpose used or diminished in quantity. Exchanges shall not be permitted if the effect thereof is to impair vested rights or to cause damage for which no compensation is paid. Water from another watershed or source which enters the Bear River by actions within a State may be claimed exclusively by that State and use thereof by that State shall not be subject to the depletion limitations of Articles IV, V and VI. Proof of any claimed increase in flow shall be the burden of the State making such claim, and it shall be approved only by the unanimous vote of the Commission.

**ARTICLE X**

A. The following rights to the use of Bear River water carried in interstate canals are recognized and confirmed.

| Name of Canal | Date Of Priority | Primary right Second-feet | Lands irrigated Acres | State |
|---|---|---|---|---|
| Hilliard East Fork | 1914 | 28.00 | 2,644 | Wyoming |
| Chapman | 8-13-86 | 16.46 | 1,155 | Wyoming |
| | 8-13-86 | 98.46 | 6,892 | Utah |
| | 4-12-12 | .57 | 40 | Wyoming |
| | 5-3-12 | 4.07 | 285 | Utah |
| | 5-21-12 | 10.17 | 712 | Utah |
| | 2-6-13 | .79 | 55 | Wyoming |
| | 8-28-05 | 134.001 | | |
| Francis Lee | 1879 | 2.20 | 154 | Wyoming |
| | 1879 | 7.41 | 519 | Utah |

Under the right as herein confirmed not to exceed 134 second-feet may be carried across the Wyoming-Utah State line in the Chapman Canal at any time for filling the Neponset Reservoir, for irrigation of land in Utah and for other purposes. The storage right in Neponset Reservoir is for 6,900 acre-feet, which is a component part of the irrigation right for the Utah lands listed above.

All other rights to the use of water carried in interstate canals and ditches, as adjudicated in the State in which the point of diversion is located, are recognized and confirmed.

B. All interstate rights shall be administered by the State in which the point of diversion is located and during times of water emergency, such rights shall be filled from the allocations specified in Article IV hereof for the Section in which the point of diversion is located, with the exception that the diversion of water into the Hilliard East Fork Canal, Lannon Canal, Lone Mountain Ditch, and Hilliard West Side Canal shall be under the administration of Wyoming. During times of water emergency these canals and the Lone Mountain Ditch shall be supplied from the allocation specified in Article IV for the Upper Wyoming Section Diversions.

**ARTICLE XI**

Applications for appropriation, for change of point of diversion, place and nature of use, and for exchange of Bear River water shall be considered and acted upon in accordance with the law of the state in which the point of diversion is located, but no such application shall be approved if the effect thereof will be to deprive any water user in another state of water to which he is entitled, nor shall any such application be approved if the effect thereof will be an increase in the depletion of the flow of the Bear River and its tributaries beyond the limits authorized in each State in Articles IV, V and VI of this Compact. The official of each State in charge of water administration shall, at intervals and in the format established by the Commission, report on the status of use of the respective allocations.

**ARTICLE XII**

Nothing in this Compact shall be construed to prevent the United States, a signatory State or political subdivision thereof, person, corporation, or association, from instituting or maintaining any action or proceeding, legal or equitable, for the protection of any right under State or Federal law or under this Compact.

**ARTICLE XIII**

Nothing contained in this Compact shall be deemed

1. To affect the obligations of the United States of America to the Indian tribes;
2. To impair, extend or otherwise affect any right or power of the United States, its agencies or instrumentalities involved herein; nor the capacity of the United States to hold or acquire additional rights to the use of the water of the Bear River;
3. To subject any property or rights of the United States to the laws of the States which were not subject thereto prior to the date of this Compact;
4. To subject any property of the United States to taxation by the States or any subdivision thereof, nor to obligate the United States to pay any State or subdivision thereof for loss of taxes.

**ARTICLE XIV**

At intervals not exceeding twenty years, the Commission shall review the provisions hereof, and after notice and public hearing, may propose amendments to any such provision, provided, however, that the provisions contained herein shall remain in full force and effect until such proposed amendments have been ratified by the legislatures of the signatory States and consented to by Congress.

**ARTICLE XV**

This Compact may be terminated at any time by the unanimous agreement of the signatory States. In the event of such termination all rights established under it shall continue unimpaired.

**ARTICLE XVI**

Should a court of competent jurisdiction hold any part of this Compact to be contrary to the constitution of any signatory State or to the Constitution of the United States, all other severable provisions of this Compact shall continue in full force and effect.

**ARTICLE XVII**

This Compact shall be in effect when it shall have been ratified by the Legislature of each signatory State and consented to by the Congress of the United States of America. Notice of ratification by the legislatures of the signatory States shall be given by the Governor of each signatory State to the Governor of each of

the other signatory States and to the President of the United States of America, and the President is hereby requested to give notice to the Governor of each of the signatory States of approval by the Congress of the United States of America.
IN WITNESS WHEREOF, The Commissioners and their advisers have executed this Compact in five originals, one of which shall be deposited with the General Services Administration of the United States of America, one of which shall be forwarded to the Governor of each of the signatory States, and one of which shall be made a part of the permanent records of the Bear River Commission.
Done at Salt Lake City, Utah, this 22nd day of December, 1978.

For the State of Idaho:

| | | |
|---|---|---|
| (s) Clifford J. Skinner | (s) Don W. Gilbert | (s) J. Daniel Roberts |

For the State of Utah:

| | | |
|---|---|---|
| (s) S. Paul Holmgren | (s) Daniel F. Lawrence | (s) Simeon Weston |

For the State of Wyoming:

| | | |
|---|---|---|
| (s) George L. Christopulos | (s) John A. Teichert | (s) J. W. Myers |

| | |
|---|---|
| Approved: | Attest: |
| Wallace N. Jibson | Daniel F. Lawrence |
| Representative of the | Secretary of the Bear River |
| United States of America | Commission |

Amended by Chapter 254, 1979 General Session

**Last revised: Thursday, June 15, 2006**

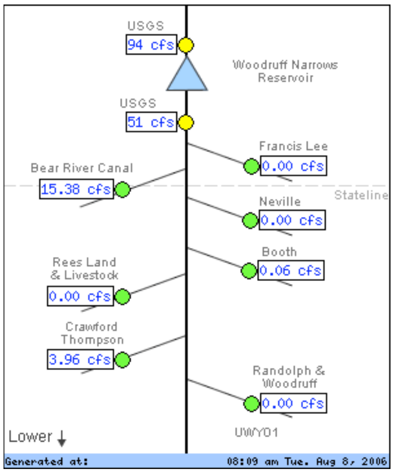
73-16-3Ratification of compact.

The compact ratified by this act is the original signed by the commissioners representing the states of Idaho, Utah, and Wyoming, and the secretary of the commission, and approved by the representative of the United States of America, and deposited in the archives of the Department of State of the United States of America and with the Division of Archives of the state of Utah.

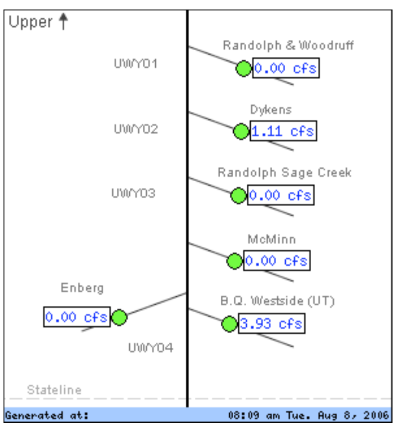
73-16-4 Members of commission.

There shall be three members of the Bear River Compact commission from the state of Utah. One member shall be the interstate stream commissioner of Utah and he shall be chairman of the Utah delegation. The other two commissioners from Utah shall be appointed by the state water and power board with the consent of the governor, and they shall hold office at the pleasure of the water and power board and until their successors shall have been appointed and qualified. Each member shall be a bona fide resident of the state of Utah and one shall be a landowner and irrigator actually residing on and operating a farm within the lower division as defined by the compact and one shall be a landowner and irrigator actually residing on and operating a farm within the upper division as defined by the compact. The Utah water and power board may with the consent of the governor appoint two alternate members of the Bear River commission. One such alternate shall be a bona fide resident of the state of Utah and a landowner and irrigator actually residing on and operating a farm within the lower division as defined by the compact and he shall be entitled to act at all regular and special meetings of the Bear River commission whenever the regular member of the commission from this same area is unable to serve and act. One such alternate shall be a bona fide resident of the state of Utah and shall be a landowner and irrigator actually residing on and operating a farm within the upper division as defined by the compact and he

shall be entitled to act at all regular and special meetings of the Bear River commission whenever the regular member of the commission from this same area is unable to serve and act. Each member of the commission from Utah shall receive a per diem plus necessary expenses, as provided by law.
73-16-5 Error in copying does not invalidate.
Any error made, if any, in copying the original compact in Section 73-16-2 hereof, shall be held not to invalidate the ratification of the compact in any way.




Name
Above Woodruff Narrows (USGS) Below
Woodruff Narrows (USGS)
Francis Lee
Bear River Canal
Neville
Booth
Rees Land & Livestock
Crawford Thompson
Randolph & Woodruff




Name
Randolph & Woodruff
Dykens
Randolph Sage Creek
McMinn
Enberg
BQ Westside

**Bear River Basin Canals Real Time Data at http://www.bearriverbasin.org/canals/**